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THE LEVEL OF COORDINATED DEVELOPMENT OF URBAN AND RURAL INFRASTRUCTURE IN GUANGDONG PROVINCE, CHINA

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ABSTRACT

Infrastructure construction influences the coordinated development of urban and rural areas in a significant way. Due to the superiority of urban infrastructure, urban development far exceeds rural development. Recognizing the large gap between urban and rural infrastructure is an urgent concern for China and other developing countries. However, the lack of a comprehensive evaluation system for coordinated development focusing on infrastructure construction is a serious challenge. This paper focuses on Maonan District, Maoming City, Guangdong Province, China, and as a case study, aims to determine the current level on coordinated development of urban and rural infrastructure. Furthermore, it provides suggestions on promotion strategies. In order to achieve the objectives, an optional evaluation list of the contribution of urban and rural infrastructure construction in Maonan District is proposed which is based on a review of relevant literature and indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. Based on the optional evaluation list, this study conducted an on-site questionnaire survey at Hongqi Street, as an urban area, and Gaoshan Town as a rural area. A total of 379 samples were collected. SPSS was applied to analyze the data obtained, and indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development were established. The result of this study determined that there are evident gaps in infrastructure development between urban and rural areas in Maonan District. In spite of urban functions being extended to rural areas, the social benefits of infrastructure in rural areas are much lower than in urban areas. In addition, the benefit of environmental and ecological in urban infrastructure is below the expected standard, highlighting the urgent need for targeted development. It also identified that the current level of urban infrastructure construction has a deep impact on coordinated development. In conclusion, this study improves the evaluation system focusing on the coordinated development of urban and rural infrastructure construction which provides valuable insights for formulating targeted strategies to strengthen the coordinated development of Maonan District and other similar areas.

Keywords:
Urban Infrastructure, Coordinated Development, Construction Evaluation, Constriction Planning, Construction Management

INTRODUCTION

Construction of physical infrastructure facilities refers to the improvement and transformation of construction projects related to infrastructure, which is the common material foundation of all enterprises, units and residents' production, operation, work and life, and the guarantee of the normal operation of main facilities (Gondia et al., 2022). However, increasing urbanization, limited land availability and high costs have resulted in urban areas that can no longer afford horizontal development strategies (Seow et al., 2022). On the other hand, in developing countries, the development of rural areas generally lags behind that of urban areas because the infrastructure in rural areas lags behind that of urban areas. The realization of coordinated development of urban and rural areas has become an urgent issue in China and many other developing countries (Shen et al., 2012).

With the rapid change of human production activities, it is necessary to constantly improve and supplement all aspects of development, the first of which is to develop infrastructure construction (Freelove et al., 2022). Urban and rural areas are different in complexity, foundation and function. To connect urban and rural areas, it is necessary to develop their physical infrastructure in a coordinated

manner. It enables urban infrastructure to reach out to rural areas, with urban services also made available to those areas. The application of civil engineering technologies is to improve rural construction's physical infrastructure, hence enhancing agricultural production conditions. At the same time, it should not only consider how the physical infrastructure of the city extends to the countryside but also consider how the original physical infrastructure of the countryside follows up and integrates into the urban areas (Wang et al., 2022). The coordinated development of physical infrastructure construction in urban and rural areas is a process of mutual benefit, common development and joint progress.

However, due to the complexity of functions and the influence of development trends, the level gap between urban and rural infrastructure construction is large, and investigation is difficult. Therefore, most of the critical factors on how different conditions affect the coordinated development of urban and rural infrastructure construction are unknown. The uncertain factors in the construction process are likely to produce serious quality problems in construction (Peng et al., 2023). As a result, due to the scientific nature of this critical factor to achieve the coordinated development of urban and rural infrastructure construction, it is studied more systematically (Shen et al., 2012). Thus, it is necessary to identify the main factors for the uncoordinated development of urban and rural infrastructure construction in order to promote the coordinated development of urban and rural infrastructure in China. It is important to focus on urban infrastructure to explore the level of coordinated development of urban and rural infrastructure construction so as to provide critical indicators for narrowing the development gap.

Infrastructure construction, like other civil engineering construction, needs to be evaluated at the latest implementation level in order to collect valuable data for the construction project to achieve the expected goal, and reduce construction risk due to decision-making mistakes. The objectives of this study are to determine the corresponding development level of urban and rural infrastructure construction, identify the problems and challenges of coordinated development, and improve the evaluation system of coordinated development of urban and rural infrastructure construction. The research area of this study is Maonan District, Maoming City, Guangdong Province, China, and its specific scope is Hongqi Street urban area and Gaoshan Town rural area. First of all, according to the evaluation system of coordinated development of infrastructure projects proposed by Shen et al. (2012), a list of optional evaluation indicators for urban and rural infrastructure construction and development in Maonan District is determined. Then, a questionnaire was made according to the list of indicators to obtain relevant data. The gaps, problems and challenges in infrastructure construction will be combined with more systematic and scientific indicators to assess the contribution of infrastructure construction to the coordinated development of urban and rural areas. Finally, an evaluation system of coordinated development of urban and rural infrastructure construction is established with Maonan District as a case study. The evaluation system is not just an upgrade in the evaluation method of construction projects but also can provide vital strategies for planning and managing the development of urban and rural infrastructure.

LITERATURE REVIEW

Infrastructure construction plays a central role in balancing urban development and ecological civilization, and is a new tool to promote urban and rural coordinated development (Wang et al., 2022). According to researchers of urban balanced development (Wu et al., 2021), the balance of infrastructure is the key driving force for regional development, but the gap between urban and rural areas is still wide, with urban developing too fast and rural developing too slowly.

Infrastructure construction is a system related to power, water, transportation and e-communication, which aims to meet the needs of regional development, ensure the normal operation of the region and provide important services for the region (Gondia et al., 2022). Physical

infrastructure is the general term for all kinds of basic material facilities and related products and services that guarantee the normal production and life of a region (Mbuligwe, 2019). The development of infrastructure projects has been an important means to promote the coordinated development of cities in developing countries such as China (Shen et al, 2012).

There are many types of infrastructure in urban areas, classified according to their main purpose, which is to meet the economic, social and environmental development of the urban areas. Urban construction focusses on housing, commercial development, public transport, public services, etc (Wu et al., 2021). More and more aspects of the daily life of people in cities depend to a large extent on large-scale infrastructure systems, including rail, road, water, telecommunications networks, gas and power (Avritzer et al., 2015). Transport infrastructure affects economies and societies, creating favorable conditions for the movement of people and goods. The continuous technological progress has forced the development of transportation and communication infrastructure (Kadyraliev et al., 2022). Urban water systems, which can provide broader social and environmental benefits, mainly in terms of water supply and water treatment, are under increasing pressure due to continued development such as climate change, population growth and urbanization (Nieuwenhuis et al., 2022). At present, in urban development planning, economic and social factors are given priority, and the environment is often the last concern. Although more and more studies are focused on the urban environment, the infrastructure of urban areas is currently composed mainly of transportation, electricity supply, water supply and treatment, and e-communications.

Rural areas usually refer to a geographical area outside of urban areas. China has the largest population of migrant workers in the world. It is a country with deep rural roots, with 56% of the population still living in rural areas (Long et al., 2011; Cheng et al., 2021). This means that the development of rural areas has a huge impact on the whole (e.g. economic, social and environmental). If it is well developed, it will be a great contribution to the balanced development of urban and rural areas. According to previous studies, infrastructure construction plays a dominant role in rural development. Rural areas often lack public transport construction. Transport services are provided less frequently, and private vehicles are often the only option to travel in rural areas (Truden et al., 2022). Implementing infrastructure projects such as roads in rural areas can greatly reduce the production and transportation costs of agriculture and agricultural products, improve the effectiveness and efficiency of economic activity in rural areas, and reduce the impact of natural disasters on farmers. Water conservation, water supply and treatment, sewage and garbage disposal can contribute to coordinated urban ecological development. Electricity and communications in rural areas can boost business and the quality of life in those areas. (Shen et al., 2012). Rural energy refers to energy utilization activities, which are closely related to people in rural areas. Rural energy is an important part of China's energy structure. Energy consumption in rural areas accounts for a large proportion of China's energy consumption. Rural energy consumption per capita has exceeded urban energy consumption. Therefore, it is of great significance to study the current situation and development potential of rural energy (Long et al., 2022). According to previous studies, the development of rural infrastructure construction should not only improve the traditional infrastructure construction level of transportation, water supply and treatment, and energy (electricity) supply, but also develop new infrastructure construction of information technology, such as e-communication and internet.

The coordinated development of urban and rural areas refers to the formation of a special relationship between urban and rural areas in spatial distribution, economic investment, ecological environment, social services and other aspects, which means that urban and rural residents may have different lifestyles, but can enjoy similar basic living conditions. If there is a high degree of coordination between urban and rural development, resources can be evenly distributed between urban and rural areas; furthermore, cities will further deprive rural areas of development resources (Tang et al., 2020). Kadyraliev et al. (2022) believe that the better connection between less-developed regions and regions with higher economic and commercial activities has contributed to the easier inflow of production factors, including knowledge, technology, and opportunities to improve the

skills of the workforce. The development of rural areas in developing countries generally lags behind that of urban areas because infrastructure in rural areas has not been adequately considered. In other words, to coordinate the development of urban and rural areas, we should take into account the economic, environmental and social development of urban and rural areas as a whole. At the same time, priority should be given to rural areas when formulating regional development plans (Shen et al., 2012). A key aspect of the inherent complexity of infrastructure projects lies in their varying task and technical complexity, as their associated scope of work often requires a high degree of technical knowledge, expertise, and significant multidisciplinary collaborative efforts (Gondia et al., 2022). This means that too much growth in any one piece of infrastructure slows down the rest. Due to the large development demand for urban construction, the development of rural infrastructure is unbalanced. For example, the research results of Wang et al. (2022) have revealed that the urbanization of infrastructure construction has a negative impact on ecosystem services, and the excessive degree of urbanization of infrastructure restricts ecosystem services. Integrating greenery into urban transport infrastructure provides multiple environmental, economic and social benefits. For example, visual contact with a green exterior can improve the mental health and comfort of citizens, especially in densely populated cities where green is lacking (Benoliel et al., 2021). Although the sewage treatment plant has sewage treatment capacity, it does not have the ecological service function. Subsurface flow constructed wetlands, as a treatment process with low cost and high pollutant removal efficiency, are commonly used in the treatment of sewage treatment tail water, and are more common in rural areas than in urban areas (Wu & Golnoosh, 2021).

Indicator System for Assessing the Contribution of Infrastructure Projects to Coordinated Urban and Rural Development

Shen et al. (2012) used mixed research methods to identify a set of indicator systems for assessing the contribution of infrastructure projects to coordinated urban and rural development. The main strategies of this method are:

Firstly, project feasibility reports, relevant literature and official reports of various infrastructure projects were reviewed to filter the indicators currently used to evaluate the contribution of infrastructure projects to coordinated urban development. This finally results in a list of optional indicators (see Table 1).

Secondly, based on this list, a questionnaire was designed in which the data collected were referred to professionals to determine the adequacy and importance of each optional indicator, examining the significance of these indicators in assessing the contribution of infrastructure projects to coordinated urban and rural development.

Table 1: Optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

No.	Optional assessment indicators
1	**Benefit indicators**
1.1	**Economic benefit**
1.1.1	IRR (internal rate of return)
1.1.2	NPV (net present value)
1.1.3	Payback (dynamic)
1.1.4	Loan repayment period
1.1.5	Return on investment
1.1.6	Return on investment before tax
1.1.7	(Direct and indirect) benefit-cost ratio of project
1.2	**Social benefit**
1.2.1	Income level
1.2.2	Living standard and quality (expressed by Engel Indicator)
1.2.3	Employment level
1.2.4	Capability to provide associated facilities (expressed by prevalence percentage)
1.2.5	Capability to provide service (expressed by coverage of service points)
1.2.6	Culture and education level, hygiene and health level
1.2.7	Safety benefit
1.2.8	Amount of benefit compensation of project stakeholders and underprivileged groups
1.2.9	Mutual adaptability indicator
1.2.10	Social risk level (expressed by social risk evaluation value)
1.3	**Environmental and ecological benefit**
1.3.1	Air pollution indicator (degree)
1.3.2	Surface water pollution degree
1.3.3	Solid waste pollution degree
1.3.4	Noise pollution indicator
1.3.5	Landscape impact degree
1.3.6	Water and soil loss impact indicator
1.3.7	Cultural relic and heritage preservation percentage (value)
1.3.8	Energy saving percentage
1.3.9	Recycled use percentage of wastes (or wastewater)
2	**Fairness indicators**
2.1	**Fairness of investment policy**
2.1.1	Preferential treatment of investment policies (for urban or rural areas)
2.1.2	Stability of investment policies
2.1.3	Support degree of investment policies
2.2	**Fairness of investment system**
2.2.1	Fairness of investors
2.2.2	Fairness of investment decision-making
2.2.3	Fairness of financing application reviewing and approval
2.2.4	Investment continuity
2.2.5	Fairness of investment supervision and administration
2.3	**Fairness of investment environment**
2.3.1	Fairness of urban and rural natural resources
2.3.2	Fairness of urban and rural public resources
2.3.3	Fairness of urban and rural energy supply
2.3.4	Fairness of urban and rural economy
2.3.5	Fairness of urban and rural income distribution
2.3.6	Fairness of urban and rural living standard
2.3.7	Fairness of urban and rural market
2.3.8	Fairness of urban and rural technology
2.3.9	Fairness of urban and rural education
2.3.10	Fairness of urban and rural employment
2.3.11	Fairness of urban and rural social security
2.3.12	Fairness of urban and rural law environment

Thirdly, using the collected data, indicators with a supportive response rate of more than 60% were selected as evaluation indicators for further research, the significance level of each indicator was calculated, and the relative significance level of each indicator was derived (see Table 2).

Table 2: Indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

Categories of indicators	Indicators	Code
Economic benefit evaluation	IRR (Internal Rate of Return)	X_{11}
	NPV (Net Present Value)	X_{12}
	Payback (dynamic)	X_{13}
	Loan repayment period	X_{14}
	EIRR (Economic Internal Rate of Return)	X_{15}
	ENPV (Economic Net Present Value)	X_{16}
	(Direct and indirect) cost-benefit ratio of projects	X_{17}
Social benefit evaluation	Employment status	X_{21}
	Living standard and quality (expressed by Engel Indicator)	X_{22}
	Capability to provide associated facilities (expressed by prevalence percentage)	X_{23}
	Culture and education level, hygiene and health level	X_{24}
	Safety benefit	X_{25}
	Amount of benefit compensation of project stakeholders and underprivileged groups	X_{26}
	Mutual adaptability	X_{27}
	Social risk level (expressed by social risk evaluation value)	X_{28}
Environmental and ecological benefit evaluation	Air pollution indicator (degree)	X_{31}
	Surface water pollution degree	X_{32}
	Solid waste pollution degree	X_{33}
	Noise pollution indicator	X_{34}
	Water and soil loss impact indicator	X_{35}
	Cultural relic and heritage preservation percentage (value)	X_{36}
	Energy saving percentage	X_{37}
	Recycled use percentage of wastes (or wastewater)	X_{38}
Fairness of investment policy	Preferential treatment of investment policies (for urban or rural areas)	X_{41}
	Stability of investment policies	X_{42}
	Support degree of investment policies	X_{43}
Fairness of investment system	Fairness of investors	X_{51}
	Fairness of investment decision-making	X_{52}
	Fairness of financing application reviewing and approval	X_{53}
	Investment continuity	X_{54}
	Fairness of investment supervision and administration	X_{55}
Fairness of investment environment	Fairness of urban and rural natural resources	X_{61}
	Fairness of urban and rural public resources	X_{62}
	Fairness of urban and rural energy supply	X_{63}
	Fairness of urban and rural economy	X_{64}
	Fairness of urban and rural income distribution	X_{65}
	Fairness of urban and rural living standard	X_{66}
	Fairness of urban and rural technology	X_{67}
	Fairness of urban and rural education	X_{68}
	Fairness of urban and rural employment	X_{69}
	Fairness of urban and rural social security	X_{610}
	Fairness of urban and rural law environment	X_{611}

Finally, a system of critical indicators was established to assess the contribution of infrastructure projects to promote coordinated urban-rural development. The indicator system consists of 19 critical indicators, covering 6 dimensions: economic benefit, social benefit, environmental and ecological benefit, equity of investment policy, equity of investment system and equity of investment environment (see Figure 1).

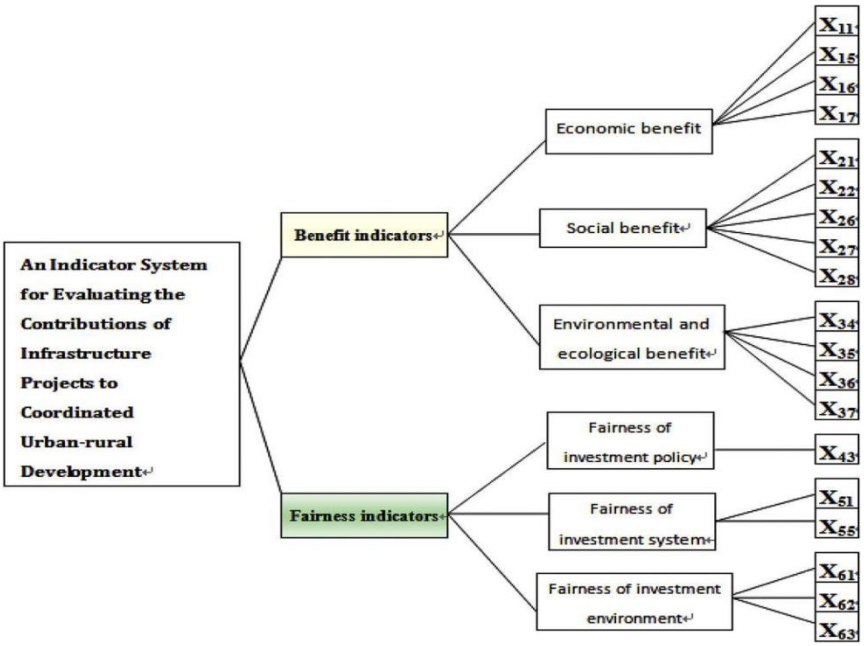


Figure 1: An indicator system for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

Social Impact Indicators

Transportation infrastructure, as an important part of the social transportation system, has become one of the main items affecting the process of urbanization. Transportation is the core of social development in geographical space. Perfect transportation infrastructure can promote the flow of various production factors and constantly promote the process of urbanization. With the continuous improvement of science and technology, the demand for transportation infrastructure is also increasing. Influenced by the improvement of income level and urbanization level, car ownership keeps rising, and traffic pressure increases accordingly (Kadyraliev et al., 2022; Nikolaev et al., 2022; Arts et al., 2021; Yannis et al., 2022).

Rural transportation infrastructure is a necessary condition to promote the smooth development of rural economy and villagers' production and life. Transportation infrastructure is especially important in rural areas where private transportation is the only option for people to get around, with few public transportation facilities. Without good transportation facilities, rural areas cannot introduce all kinds of equipment and technology, and it is difficult to promote all kinds of development (Long et al., 2011; Ma et al., 2021; Shen et al., 2012; Truden et al., 2022). To sum up, transportation infrastructure plays an important role in the development of urban and rural areas. It could even be said to be the most critical factor.

Environmental & Ecological Impact Indicators

Water is essential in people's daily life. Water supply and treatment are therefore important components of urban and rural infrastructure. In order to guarantee people's living and industrial production, a region must have a perfect sewage treatment system. Water supply facilities are important urban infrastructure, which is an important support for ensuring and improving people's livelihood and promoting the coordinated development of urban and rural areas. Issues such as

rainstorm weather, urban water logging, smooth drainage, and water pollution have been the focus of the problem. Of course, rural areas are no exception. (Avritzer et al., 2015; Shen et al., 2012; Nieuwenhuis et al., 2022).

Energy consumption in urban areas is huge and only electricity power can be supplied to a greater extent. Energy demand in rural areas is not as great as in urban areas, but electricity has become a demand in rural areas. Especially with the development trend of electric power technology, electric infrastructure is essential. Electricity power is the main energy source at present. Electricity power is the key point to promote the energy transition and achieve the goal of carbon peak carbon (Avritzer et al., 2015; Long et al., 2022).

With the continuous development of internet technology, it has played a very important role in the development of urban areas. Nowadays, life has been completely inseparable from internet technology. In both urban and most rural areas, daily communication is almost exclusively electronic. More and more energy management uses Internet technologies, such as the use of ICT cards to manage the cost of water, electricity and gas supplies; REI are proposed to monitor and manage rural living, farming and other related energy activities (Avritzer et al., 2015; Long et al., 2022).

As the foundation of human existence and development, land resources are an important source of all production and all existence. The same plot of land will have varied results depending on the edges, time, shape, and other factors. Therefore, land must be developed under a good planning strategy (Tang et al., 2020; Wu et al., 2022; Ma et al., 2021).

Optional Indicators

In this study, the determination of the optional indicators for evaluating the contribution of infrastructure projects to coordinated urban development is based on the summary of previous relevant literature and the analysis of influencing factors. As mentioned above, infrastructure projects have two main influences on coordinated urban development: Social and Environmental & Ecological.

Based on the evaluation model of Shen et al. (2012), the optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural are listed in Table 3.

Table 3: Optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Made by author)

No.	Optional assessment indicators
	Benefit indicators
1	**Social benefit**
1.1	Road
1.2	Bridge
1.3	Highway
1.4	Railway
1.5	Subway
1.6	Bus Station
2	**Environmental and ecological benefit**
2.1	Water supply
2.2	Wastewater treatment
2.3	Internet technology
2.4	Power supply
2.5	Solid waste
2.6	Greenery
2.7	Land planning

RESEARCH METHODOLOGY

Research Design

In reference to previous literature reviews and research, and the indicators system (Shen et al., 2012), the Indicators for Evaluating the Contribution of Infrastructure Projects to Coordinated Urban-Rural Development were determined as per Table 4. Then, based on this list, a questionnaire was designed to determine the adequacy and importance of each optional indicator through the people concerned. Questionnaire surveys are usually open-ended so that in-depth data and information can be collected. It is a social research method in the professional field.

Table 4: Indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. (Made by Author)

Categories of indicators	Indicators	Code
Social benefit evaluation	Road	X 11
	Bridge	X 12
	Highway	X 13
	Railway	X 14
	Subway	X 15
	Bus Station	X 16
Environmental and ecological benefit evaluation	Water supply	X 21
	Wastewater treatment	X 22
	Internet technology	X 23
	Power supply	X 24
	Solid waste disposal	X 25
	Greenery	X 26
	Land planning	X 27

This questionnaire is designed according to the indicators system in Table 4 based on Shen et al. (2012) and Benoliel et al. (2021). The questions in the questionnaire survey were designed and structured to match the research objectives to obtain the requirement. The questionnaire is divided into four sections.

- Section A: Demographic Information
- Section B: The Construction Level of Urban Infrastructure
- Section C: Problems and Challenges Existing in the Level of Urban Infrastructure Construction to Promote Coordinated Development
- Section D: The Strategy of Promoting the Coordinated Development of Urban and Rural Infrastructure Construction

Sample Size of Population

In order to reflect the significance of the case study, Hongqi Street in Maonan District is selected as a case study for urban areas, and Gaoshan Town as a case study for rural areas. Hongqi Street which belongs to Maonan District is located in the southwest of Maoming City. It has an area of 6 square kilometers and a population of 8,598. Gaoshan Town, belonging to Maonan District, is located in the southwest of Maoming City. It is the typical suburban junction with an area of 12.19 square kilometers and a population of 18,119. The two areas, with a total population of 26,717, are adjacent and have frequent activities between them, which makes it easier to show the difference between urban and rural infrastructure construction. In this study, an online sample calculator (*https://www.calculator.net/sample-size-calculator.html*) was used to obtain the sample size. Based

on the calculation with a confidence level of 95% and an error of5%, the sample size of the survey should be 379. For the principle of data fairness, the sample size of 379 is divided according to the proportion of each region in the total population. A total of 122 respondents were randomly surveyed in Hongqi Street. A random survey of 257 respondents was conducted in Gaoshan Town.

Data Collection & Analysis

In this study, quantitative methods were adopted. Quantitative research emphasizes predictive control, the objective reality of facts, and experiential verification. This will be used in all sections. The quantitative method is also used to summarize the data and information of the whole questionnaire. The type of questionnaire is the on-situ survey method in the form of Statistical Package for Social Sciences (SPSS). It targets both urban and rural residents in Maonan District, Maoming City, Guangdong Province, China. The questionnaire was processed by Word software, and the relevant urban and rural residents were surveyed and recorded through electronic social software. The respondents were asked to answer the questions truthfully. The researcher then analyzed and summarized the information gathered from the questionnaire in order to achieve the aims and objectives related to this study.

RESULTS AND DISCUSSION

Section A: Demographic Information

Table 5 shows a detailed summary of Respondents' Demographic in the urban area and rural area. The results showed that all respondents were working people between the ages of 20 and 60. Most respondents from both urban and rural areas work in urban areas. Respondents in rural areas have lower income and lower education levels compared to those in urban areas. The mobility of residence rates in urban areas is greater than in rural areas. Overall, a disharmony between urban and rural infrastructure construction and development is found, where most respondents believed that conditions in urban areas are better than those of rural areas.

Table 5: Respondents' Demographic in Two Areas

Demographic	**Classification**	**Percentage (%)**	
		Urban Area (Hongqi Street)	**Rural Area (Gaoshan Town)**
Age	10-20	0	0
	20-60	100	100
	>60	0	0
	Mean	2.00	2.00
Work Status	Yes	100	100
	No	0	0
	Mean	1.00	1.00
Possession of Car	Yes	59.02	40.98
	No	58.75	41.25
	Mean	1.44	1.57
Education Level	Primary School	0	0
	Middle School	34.43	43.97
	High School	39.34	33.85

	University	26.23	22.18
	Mean	2.78	2.71
Enough Monthly Income	Yes	72.13	57.95
	No	27.87	42.41
	Mean	1.28	1.57
Work Area	Urban Area	82.79	85.99
	Rural Area	17.21	14.01
	Mean	1.17	1.00
Duration of Residence	Long-term Living	83.61	90.27
	Short-term Living	16.39	9.73
	Mean	1.17	1.00

Section B: The Construction Level of Urban Infrastructure

Table 6 shows the analysis for the current level of infrastructure of both areas. The construction level was ranked based on 1 to 5 (where 1 = very bad; 2 = bad; 3 = medium; 4 = good; and 5 = very good). The power supply (Scale = 4) in urban and rural areas are both rated good, with a mean of 4.17 in urban areas and 4.14 in rural areas. It means that the level of infrastructure construction of power supply is relatively coordinated currently. The worst infrastructure in both regions is land (scale=1), with a mean of 1.83 in urban areas and 1.00 for rural areas. This reflects that there is a large gap in the coordinated development of urban and rural infrastructure construction. By contrast, the level of infrastructure construction in urban areas is obviously higher than that in rural areas.

Table 6: The Construction Level of Urban and Rural Infrastructure

Infrastructure	**Urban Area (Hongqi Street)**		**Rural Area (Gaoshan Town)**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Water Supply	4.00*	0.34	3.14	0.85
Water Treatment	4.00*	0.67	2.00	0.00
Road	4.22*	0.42	3.14	0.36
Bridge	3.28	0.65	2.71	0.46
Internet	4.39*	0.49	3.71	0.71
Power Supply	4.17*	0.38	4.14*	0.36
Disposal of Solid Waste	3.21	0.98	2.29	0.71
Land	1.83	0.38	1.00	0.00

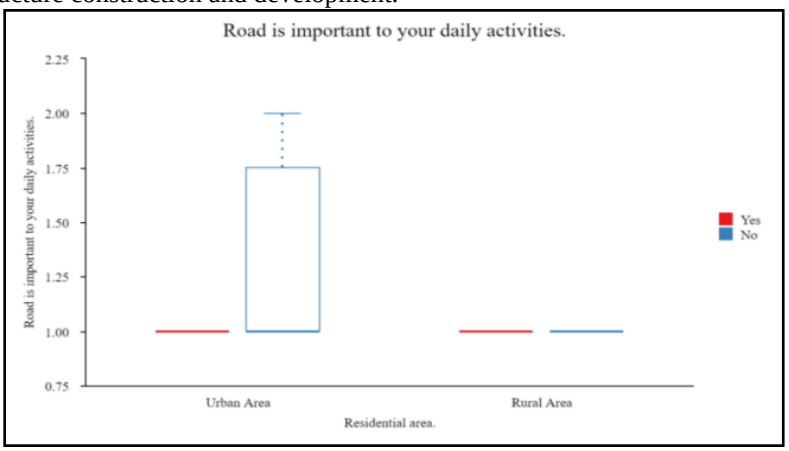
*(*Note: scale of 1–5: 1 = very bad; 2 = bad; 3 = medium; 4 = good; and 5 = very good.)*

Discussion of Finding in Section B: The Level of Infrastructure Construction In Urban Areas Is Much Higher Than That In Rural Areas

According to the final part of Section B of the questionnaire survey, the internal infrastructure construction in most urban areas of China maintains high-quality development, but the development trend is obviously rising, and diversified and complicated. There is a big gap between urban and rural development of infrastructure construction. It shows that the planning and management for the coordinated development of urban and rural infrastructure construction in China is still inadequate, especially the lack of a set of systematic evaluation systems. The study shows that infrastructure construction in most cities currently focuses on the development of urban areas in China.

Section C: Problems and Challenges Existing in the Level of Urban Infrastructure Construction to Promote Coordinated Development

Figure 2 shows whether ownership of a private car impacts the importance of roads to the respondents. Through the boxplot, it can be seen that the construction of road infrastructure has a great impact not only on activities using private cars but also on non-private car activities. Secondly, it reflects that the diverse urban transportation infrastructure makes urban respondents who do not own a car have a great difference in their views on the importance of roads. Therefore, there are many unstable factors in road construction, which brings more challenges to the coordination of urban and rural road infrastructure construction and development.



*(*Note: scale of 1–2: 1 = Important; 2 = Not important.)*
Figure 2: The impact of private cars on the importance of roads

Figure 3 shows the importance of bridges to respondents who own and don't own a private car. Notably, there was a trend of intersection between respondents who thought bridges were very important (53%) and those who thought bridges were not (47%). This suggests that bridges in some areas have little or no impact on private car use. This means that bridges mainly have the greatest impact on travel activities, such as the use of private cars. Besides, with the change in the number of private cars owned by residents, the development of bridge infrastructure construction also has great fluctuations, especially in the aspect of coordinated development between urban and rural areas.

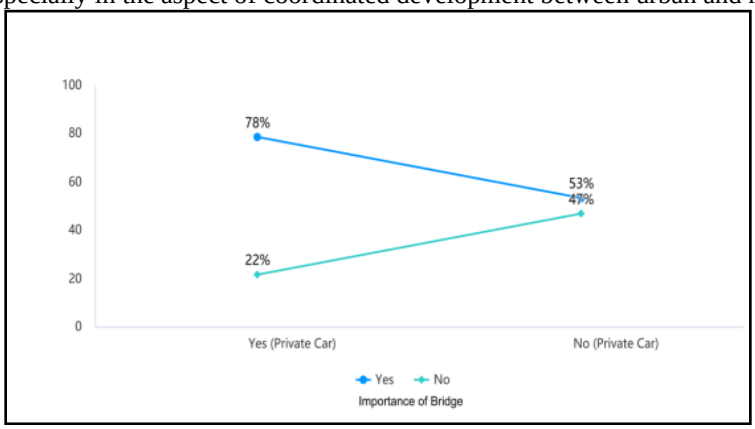


Figure 3: The impact of ownership of private cars on the importance of bridge

Figure 4 shows the importance of internet infrastructure construction to the daily life of urban and rural residents. It can be seen that all urban respondents (100%) think the internet is important, while most rural respondents (89.88%) also think the internet is important. It shows that in the internet times, people's demand for internet infrastructure construction is great. While urban areas are still in urgent need of development, if the coordinated development of urban and rural internet infrastructure has not been given due attention, the gap will be even wider. This is especially so in terms of the top-down characteristics of internet infrastructure construction, with the challenge of coordinated development between urban and rural areas being greater.

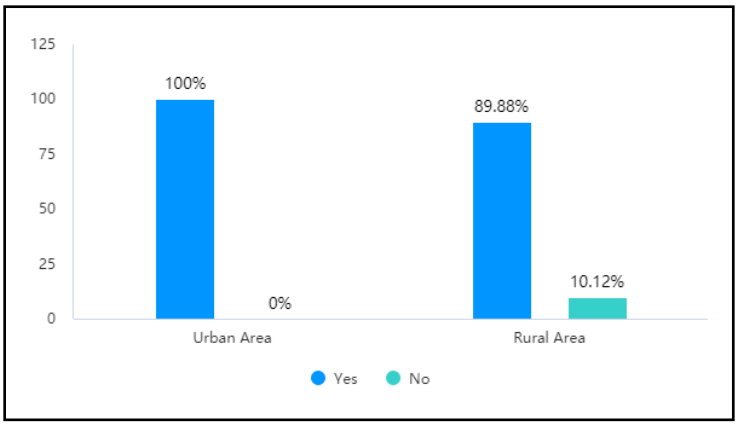
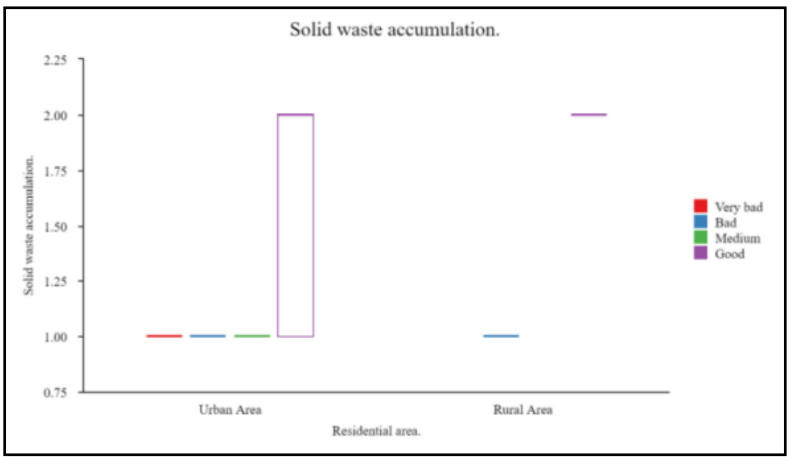


Figure 4: The importance of the internet

Figure 5 shows the solid waste accumulation in different statuses of solid waste disposal in urban and rural areas. It can be seen that the trend of solid waste accumulation near the residence is obviously inconsistent with the status of solid waste disposal. Solid waste accumulation tends to be consistent with the status of solid waste disposal. For example, the solid disposal treatment is better where the solid waste accumulation is less. This means that the development of solid waste treatment infrastructure construction is still low, and more factors need to be considered.



*(*Note: scale of 1–2: 1 = No accumulation; 2 = Accumulation.)*

Figure 5: Solid waste accumulation

Figure 6 shows the effects of water supply status on smooth water supply in urban and rural areas. It can be seen that the construction of water supply infrastructure in the urban areas records medium, good and very good status, and all urban respondents believe that the water supply is smooth. Even in the few places in the urban area where the water supply is very bad, there are still people who believe that the water supply is smooth. Obviously, the water supply in urban areas is at a perfect level, and the challenge for the coordinated development of urban and rural water supply infrastructure is how to develop rural areas without neglecting to maintain the perfect level of water supply in urban areas.

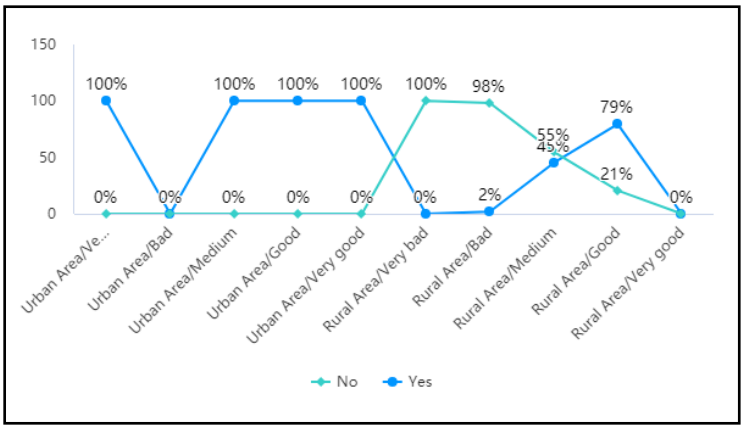


Figure 6: The Effect of Water Supply Status on Smooth Water Supply

Figure 7 shows the effect of wastewater treatment status on sewage discharge satisfaction. The effect trend in urban areas fluctuated little, while that in rural areas increased slowly. This means that the development trend of wastewater treatment infrastructure construction is slow, especially the huge difference, which brings double challenges to the coordinated development of urban and rural areas.

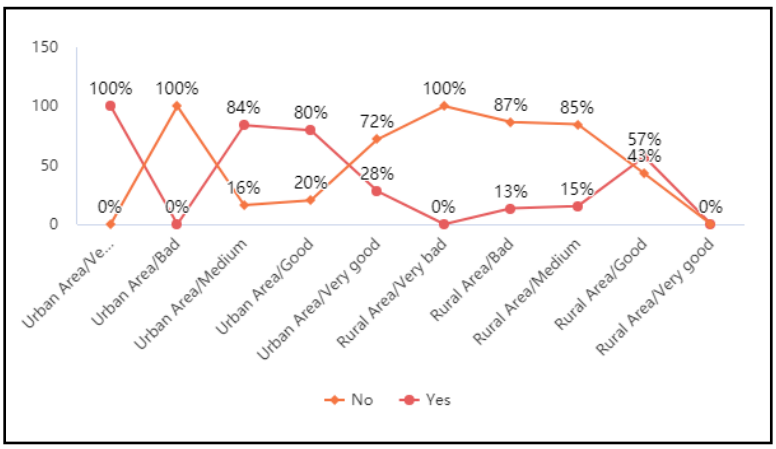


Figure 7: The effect of wastewater treatment status on sewage discharge satisfaction

Figure 8 shows that the effect of power supply status on power supply satisfaction. As can be seen, urban respondents are satisfied that the power supply in urban areas remains in good and very good condition. For the coordinated development of urban and rural power supply infrastructure

construction, rural areas with relatively backward development levels and large horizontal spans will face more challenges.

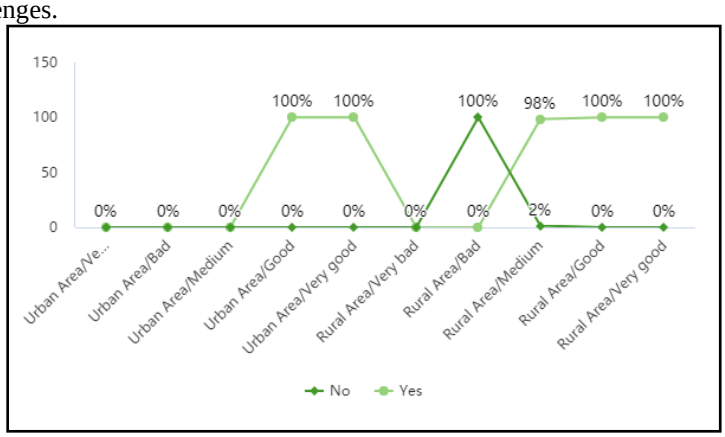


Figure 8: The effect of power supply status on power supply satisfaction

Figure 9 shows the effect of abandoned land on greenery. Obviously, for urban respondents, those who have abandoned land near their area think that the afforestation level is in bad or very bad state. This is contrary to the situation in rural areas, indicating that the situation of abandoned land in urban areas is not the same as that in rural areas. Respondents who think that there is no abandoned land in urban areas think that the greening level is in a bad or medium state, which indicates that the area of abandoned land in urban areas has little influence on greening. It means that urban and rural land development is very uncoordinated, and for urban areas under the premise of complex infrastructure, the reasonable development of green will face a lot of obstacles.

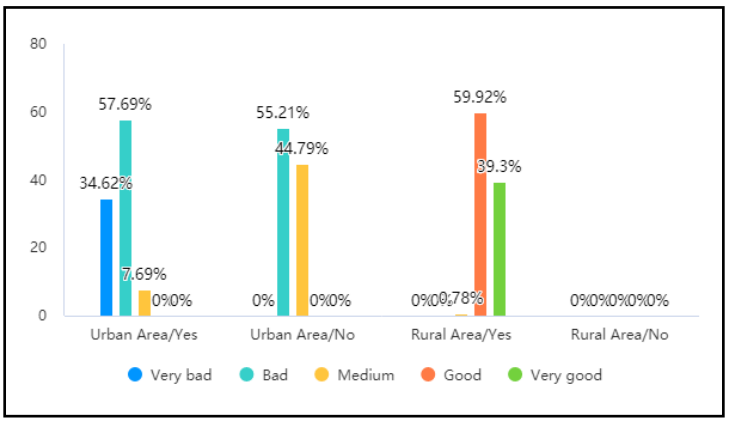


Figure 9: The effect of abandoned land on greenery

Discussion of Finding in Section C: The Lack of a Perfect Evaluation System and The Complexity of Different Individual Conditions on Demand Are the Barriers and Challenges to The Uncoordinated Development of Urban and Rural Infrastructure Construction

From Section C, it can be found that many respondents' satisfaction with infrastructure is greatly affected by their personal circumstances, such as whether the respondents own a vehicle in terms of their views on transportation infrastructure. Therefore, the obstacle to the coordinated development of urban and rural infrastructure construction is the evaluation system. As we all know, the premise of planning and management of construction projects is the survey. Without scientific and high-quality surveying, there is no high-quality planning or design. Management is then difficult. For infrastructure construction, evaluation is very important. It can help engineers collect more information and data in the formulation of urban and rural planning, so as to better understand and analyze the current situation, making decisions more effective. Although there are already perfect evaluation systems and survey methods for engineering construction in China, there is no perfect evaluation system for the topic of coordinated development of urban and rural infrastructure construction. Even though the current infrastructure construction has a systematic life-cycle process of survey-evaluation-design-planning-construction-management in China, evaluation is also a prerequisite to support the correct implementation of infrastructure construction projects. If there is no evaluation system for the coordinated development of urban and rural infrastructure construction, the coordination of urban and rural infrastructure construction cannot be formed.

Section D: The Strategy of Promoting the Coordinated Development of Urban and Rural Infrastructure Construction

Figure 11 shows the priority for infrastructure construction. As can be seen, transportation has the highest percentage (29.29%), followed by water treatment (29.02%), solid waste disposal (15.83%), ecological environmental protection (12.40%), water supply (10.03%), and the Internet (3.43%). Transportation infrastructure is a prerequisite for the development of the rest of the infrastructure construction. Without transportation, it is difficult to carry out respective production activities. So, it makes sense to put transport infrastructure first. Water treatment is preferred over water supply because substandard water treatment will directly affect the quality of water supply. Water is a daily necessity for people. So, it is reasonable to prioritize water treatment over water supply. It is noted that the proportion of solid waste disposal and ecological environmental protection is similar, indicating a close relationship between the two. The harmful substances contained in solid waste and its leaking liquid will change the properties and structure of soil and have a serious adverse impact on crops, plant growth and soil environmental quality. Therefore, solid waste treatment is beneficial to the development of ecological environmental protection to a large extent. Internet infrastructure construction is characterized by top-down and advanced professional technology. The development of internet infrastructure must depend on professional scientific research. The time span is large, hence its ranking at the bottom makes sense.

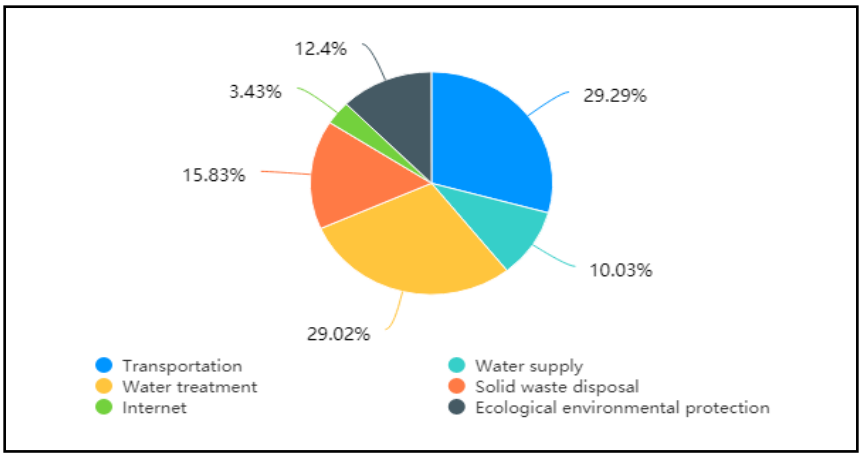


Figure 11: The priority for infrastructure construction

Table 7 shows the correlation and significance level between respondents' priority for infrastructure construction with the independent variable and the current level of urban and rural infrastructure construction with the dependent variable. Spearman's Rho correlation (r) and significance level (p) were applied to the results of this analysis.

As a result, respondents' priority for infrastructure construction and the current level of urban and rural infrastructure construction not only show 0.01 level of significance but also have a significant positive correlation. ($r > 0$ indicating that there is a significant correlation between variables; $p<0.01$ indicating that a significant correlation between variables).

Table 7: Correlation between Respondents' Priority for Infrastructure Construction and Current Level of Urban and Rural Infrastructure Construction

	Independent Variable - Respondents' Priority for Infrastructure Construction	
Dependent Variable - Current Level of Urban and Rural Infrastructure Construction	**Spearman's Rho (r)**	**Significant Level (p)**
The status of water supply	0.411	0.000
The status of wastewater treatment	0.667	0.000
The status of roads	0.522	0.000
The status of bridge	0.864	0.000
The status of E-communication, WIFI, etc.	0.815	0.000
The status of power supply	0.290	0.000
The status of disposal of solid waste (e.g. household waste)	0.753	0.000
Abandoned land	0.587	0.000

Figure 12 shows the importance of infrastructure for traveling to all respondents. As can be seen, road accounted for the most (46.97%), followed by bus stops (43.01%). Bridges ranked third (6.60%) followed finally, by railways (3.43%). The proportion of highways and subways is 0.

Road is the most widely used in all transportation infrastructure construction, and is also the premise of the rest of the transportation infrastructure construction and development. Bus station is a mass benefit in the construction of transportation infrastructure, which can obviously promote the efficiency of transportation. The bridge is the closest to the function and attribute of the road, but the function of the bridge is limited, such as height and weight limit. Due to this, some vehicles cannot enter, and because the bridge structure leads to the cost and maintenance cost is higher than the road, the importance of the bridge is far less than the road. The use of railways allowed large quantities of goods to be transported simultaneously, more efficiently than road transport.

Highways are often used for intercity transportation, not urban and rural transportation within a city. Subways are difficult to build and have the highest cost of construction and maintenance. Besides, it is only used in the economic and business centers of megacities. Therefore, subway is not suitable for most cities.

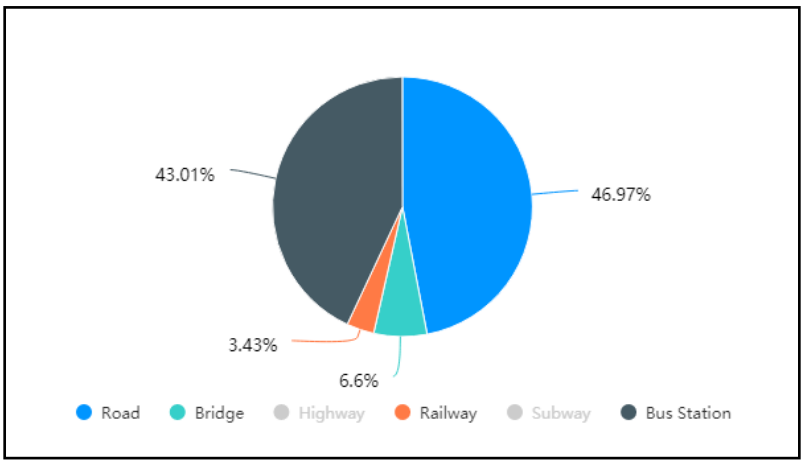


Figure 12: The important infrastructure for traveling

Based on the data derived from the priority for infrastructure construction in Table 8 and Figure 11 as well as the important infrastructure for traveling in Table 9 and Figure 12, the following inequality (1) & inequality (2) were found:

X11 (46.97%) > X12 (43.01%) > X16 (6.6%) > X14 (3.43%) (1)
X22 (29.02%) > X25 (15.83%) > X26 (12.4%) > X21 (10.03%) > X23 (3.43%) (2)

Table 8: The priority for infrastructure construction from respondents

Priority for Infrastructure Construction	**Respondents**	
	Mean	**Standard Deviation**
Transportation	1.25	0.44
X12 (Water treatment)	2.00	0.00
X25 (Solid waste disposal)	1.17	0.38
X26 (Ecological environmental protection)	1.00	0.00

Table 9: The Status of Road, Bridge and Bus Station Impact on The Important Infrastructure for Traveling

The Status of Transportation Infrastructure	**Important Infrastructure for Traveling**					
	1.0		**2.0**		**6.0**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
X11 (Road)	3.83	0.38	3.64	0.50	4.10	0.82
X12 (Bridge)	2.74	0.44	3.18	0.40	3.52	0.67
X16 (Bus Station)	2.72	1.17	4.18	0.98	5.00	0.00

Discussion of Findings in Section D: Indicators for Evaluating the Contribution of Infrastructure Construction to Coordinated Urban-Rural Development

By discussing the data analyzed, we can obtain some basis for ranking the contribution indicators of infrastructure. In particular, greenery is affected by the conditions of solid waste disposal; X25 (Solid waste disposal) is ranked ahead of X26 (Greenery). The development trend of power supply infrastructure construction is slow. So, it ranks behind internet infrastructure construction. Land planning, based on the development of greenery and all infrastructure, ranked last. Therefore, the final indicators for evaluating the contribution of infrastructure construction to coordinated urban-rural development can be obtained in Table 10:

Table 10: Indicators for evaluating the contribution of infrastructure construction to coordinated urban-rural development (Made by Author)

Categories of indicators	Indicators	Code
Social benefit evaluation	Road	X 11
	Bus Station	X 16
	Bridge	X 12
	Railway	X 14
Environmental and ecological benefit evaluation	Wastewater treatment	X 22
	Solid waste disposal	X 25
	Greenery	X 26
	Water supply	X 21
	Internet technology	X 23
	Land planning	X 27
	Power supply	X 24

CONCLUSION

The proposed research model was tested through a survey of urban and rural respondents in Maonan, Maoming, Guangdong, China. The results found that the level of development of infrastructure construction in China's urban areas is much higher than that in rural areas. This is because China does not have a perfect system that focuses on the coordinated development of urban and rural infrastructure construction. Finally, based on the collected data and the previous theoretical model, this study puts forward indicators for evaluating the contribution of infrastructure construction to Urban-Rural coordinated development, as a promotion strategy for coordinated development of urban and rural infrastructure construction. Therefore, future research can focus on the influence of coordinated development of urban and rural infrastructure construction on land planning, because infrastructure construction has the greatest demand for land. In addition, it is also possible to further study on forming a system for coordinated development of urban and rural infrastructure construction.

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MECHANICAL PROPERTIES AND SUSTAINABILITY OF ALUM SLUDGE AS A PARTIAL REPLACEMENT OF FINE AGGREGATE

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ABSTRACT

A substantial volume of alum sludge is generated globally during the water purification process for human consumption. The existing studies have highlighted that the conventional disposal methods pose significant environmental challenges, necessitating the exploration of more sustainable alternatives for alum sludge disposal. This research aims to investigate the workability and compressive strength behavior of traditional concrete by incorporating dry alum sludge as a replacement for fine aggregate (river sand). The alum sludge underwent treatment at 105 °C, was dried, crushed and sieved to achieve a fine particle. This treated alum sludge was then used to replace fine aggregate at varying percentages: 5, 10 and 15%. Specimens were prepared in cube forms (100×100×100mm) targeting a compressive strength of 25 MPa. The study aimed to understand the impact on the filler material properties, workability and strength of both fresh and hardened concrete. The compaction factor test and slump test results were employed to identify the fresh properties of the concrete. The compressive strength tests were conducted at 7, 14 and 28 days. The findings from the compressive strength tests indicated that a replacement of fine aggregate up to 10% was effective in achieving the targeted concrete strength. However, a reduction in workability was observed when the alum sludge filler was increased to 15%, while the 5% filler exhibited superior workability performance. This research contributes to altering certain aspects of concrete behavior by introducing the alum sludge as a replacement material for fine aggregate, thereby promoting environmental sustainability. The findings have sparked considerable debate in the field regarding concrete strength properties and behaviors, emphasizing the importance of exploring alternative materials for more eco-friendly construction practices.

Keywords:
Alum sludge, treated alum sludge, concrete mix, green concrete, sustainable concrete.

INTRODUCTION

As the global population continues to expand, projections indicate a doubling of water consumption by 2050. Meeting this heightened demand necessitates an increase in production by water treatment plants (WTPs), consequently leading to a surge in waste generation from treatment processes, commonly referred to as water treatment sludge (WTS). Globally, it is estimated that over 10,000 tons of sludge are generated daily. Management approaches for this waste vary among countries, often culminating in disposal in landfills, which poses significant environmental challenges. Consequently, there is a growing imperative to explore sustainable alternatives for WTS treatment and reuse, driving widespread interest among researchers. One promising avenue involves utilizing WTS as a raw material in other production processes, aligning with the principles of the circular economy. This strategy not only addresses environmental concerns but also contributes to mitigating the current challenges of natural resource scarcity (Mattoso et al., 2024).

The use of alum sludge in concrete has indeed gained significant attention among researchers. Alum sludge, which is a by-product of water treatment plants, offers potential benefits for enhancing certain properties of concrete. It is important to note that extensive research and testing are necessary to determine the optimal proportion of alum sludge in concrete mixtures to achieve the desired improvements in properties. (Ahmed et al., 2022) Investigated the mechanical characteristics of high-performance concrete incorporating alum sludge particles, with particle sizes such that 90% pass through sieve No. 200, serving as a substitute for cement at varying proportions 0, 5, 10, 15 and

20 % by mass. It may improve the mixture's workability and flow ability, making placement and compaction during construction simpler, which may increase the concrete's compressive strength. (Zhao & Zhang 2021). Factors such as the characteristics of the sludge, particle size distribution, and processing techniques need to be considered to ensure the best results which may have advantages for waste management and property improvement. Alum sludge can help to improve the characteristics of concrete when it is used in place of sand (Ching & Bashir 2021).

However, it is important to note that the proportion of alum sludge used as a sand replacement should be carefully determined through research and testing. In order to better understand how alum sludge affects the properties of concrete and to develop standards for its effective use, this research is actively investigating behavior of concrete incorporating alum sludge as fine aggregate. Also, the clay mineral content of alum sludge could potentially impact the workability of the concrete mix, particularly when used in significant quantities. This study also aims to explore the ideal alum sludge content that positively influences the workability performance of the concrete.

METHODOLOGY

Materials

This research is to determine the performance of the concrete that contains alum sludge (AS) that collected from the cake yard of a water treatment plant in Putrajaya, as shown in Figure 1. The river sand used in our study was sourced from the Kajang Quarry in Selangor. The river sand and the treated alum sludge were incorporated as fine aggregates, both falling within the particle size range bellow 2 mm. The course with the aggregate size maximum of 10mm, the cement used was ordinary Portland cement (OPC). Concrete cube samples were prepared and tested to determine various basic engineering properties. The concrete mix design involved a systematic analysis to select the appropriate ingredient proportions, aiming to produce modified concrete with desired strength and desired fresh properties when the cube is hardened. All tests conducted on the aggregate followed the standard and guidelines outlined in (BS EN 12620 2008).

Figure 1: The alum sludge is collected from cake yard, water treatment plant, Putrajaya

Preparation of materials

The sludge was collected and transported to the laboratory. Subsequently, it underwent an oven drying process at approximately 105 °C for 24 hours. After drying, the sludge was crushed and ground using a Los Angeles Abrasion test machine to achieve the desired fineness, which closely resembles the fineness of sand. To optimize the moisture content in the aggregate and eliminate any deleterious materials, the collected alum sludge must undergo treatment.

Experimental Programme

The experiments have been designed to assess various properties of alum sludge concrete (ASC), including particle grading, slump value, compacting factor and compressive strength. These tests aim to provide valuable insights into the characteristics and performance of ASC.

Concrete mix design

The mix design employed in this study followed the guidelines for normal concrete strength of 25 Mpa as per the British standard (BS 1881-108 1990). The replacement percentages ranged from 0, 5, 10 to 15 % and each mix was prepared separately. The control sample represented plain concrete without any alum sludge addition, as detailed in Table 1. The concrete curing process followed a conventional method, where different curing durations of 7, 14 and 28 days were implemented. For the assessment of compressive strength, concrete cube samples with dimensions of 100 mm were utilized. Additionally, for the evaluation of flexural strength, samples with dimensions of 100 mm x 100 mm x 500 mm were employed. These standardized sample sizes were chosen to ensure accurate and reliable testing of the concrete's strength properties. Proper curing of concrete cubes is essential to facilitate the correct hydration process. After the creation of the specimen cubes, they undergo a curing procedure involving submersion in water for varying durations, typically 7, 14 and 28 days. This curing process adheres to the guidelines outlined in (BS1881: Part III: 1983).

Table 1: Concrete mix proportion (Kg/m3)

Marking	W/C	Water	Cement	Coarse Agg.	Fine Agg.	Oven dried alum Sludge
C1	0.58	188.33	325	1200	736	0
CA5	0.58	188.33	325	1200	699	37
CA10	0.58	188.33	325	1200	662	74
CA15	0.58	188.33	325	1200	625	110

*Control sample (C) Oven dried alum sludge filler (A)

Particle Grading Test

The particle size distribution of aggregates and fillers will be determined by both representative and recovered samples will undergo sieve analysis following the guidelines of (BS 812) and (ASTM C136). This analysis focuses on measuring particle size distribution greater than 0.074 mm. The resulting particle size distribution curve will be presented for the representative soil sample. A total of 500 gm of fine aggregate will be weighed after recording the weights of the sieves and pan. The sieves will be assembled in ascending order, with larger openings on top and the No. 4 sieve at the top and the No. 200 sieve at the bottom. The fine aggregate will be placed in the top sieve and covered

with a lid. The sieve stack will then be mechanically shaken for 10 minutes. After removing the sieve stack from the shaker, the weight of each sieve will be recorded.

Slump Value Test

The slump test is a widely used method for measuring the workability of concrete, both in laboratory settings and on-site. The apparatus required for conducting the test includes a metallic mould in the shape of a frustum of a cone, with specific dimensions. A steel tampering rod is also needed. In the field tests, the concrete sample should be obtained. The internal surface of the slump cone is thoroughly cleaned and dried before the test. The cone is placed on a smooth and rigid surface, secured with clamps, and filled with freshly prepared concrete in layers each compacted with 25 strokes of the tampering rod. The excess concrete is removed, and the cone is carefully lifted vertically without disturbing the concrete cone. The slump value is then recorded as a measure of the workability of the concrete.

Compacting Factor Value

The fresh concrete was delicately placed into the upper hopper using a hand scoop, ensuring it reached the brim of the hopper. Subsequently, the trap-door was opened, allowing the concrete to flow into the lower hopper. In cases where the concrete stacked up in the hoppers, a rod could be gently pushed from the top to assist the process. Once the concrete came to rest, the cylinder needed to be uncovered, and the trap door of the lower hopper opened to allow the concrete to fall into the cylinder. Following this, any excess concrete was removed using a trowel. The weight of the cylinder with the concrete was then recorded as W1.

Next, the cylinder was emptied and refilled with the same concrete mix, layer by layer, approximately 5 cm deep. Each layer was compacted by ramming to achieve full compaction. The top surface was leveled before recording the weight of the fully compacted concrete in the cylinder as W2. Subsequently, the weight of the empty cylinder was recorded as W.

The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete.

Compressive Strength

The surface of the concrete sample was thoroughly cleaned before positioning it in the compression machine. Subsequently, the sample was centrally aligned on the base plate of the machine. The load was applied gradually at a rate of 140 kg/cm2/min until the sample reached failure. The maximum load and the mode of failure were carefully recorded.

RESULT AND DISCUSSION

Particle Grading

The particle size distribution of alum sludge closely resembled that of a fine aggregate, as shown in Figure 2. Consequently, these particles hold the potential to significantly augment the aggregate's strength by filling gaps between the coarse aggregates. Alongside evaluating the particle grading of the raw materials, tests were conducted on the fresh concrete to assess its workability, including the slump value test and compacting factor test.

The particle shapes, sizes, and quantity of fine aggregate play pivotal roles in determining both the workability and strength of concrete. The fine modulus of the locally sourced natural sand in Malaysia was determined 2.84 and alum sludge fine modulus 2.52. Additionally, specific gravity and

moisture content were measured at 2.67 and 0.86 for sand, and 2.33 and 30 % for alum sludge respectively. Coarse aggregate comprised crushed stone chips with a maximum size of 10mm for the proposed concrete mix design method. Specific gravity and moisture content of the coarse aggregate were determined in accordance with (ASTM C127) standards. The grading curve of the coarse aggregate was established following (ASTM C33) guidelines. Table 2 presents the physical properties of the fine aggregates utilized in the study.

Table 2: Physical Properties of Aggregate

Physical properties	Fine aggregate	Alum sludge
Specific gravity	2.67	2.33
Fineness modulus	2.84	2.52
Moisture content	0.63 %	30 %

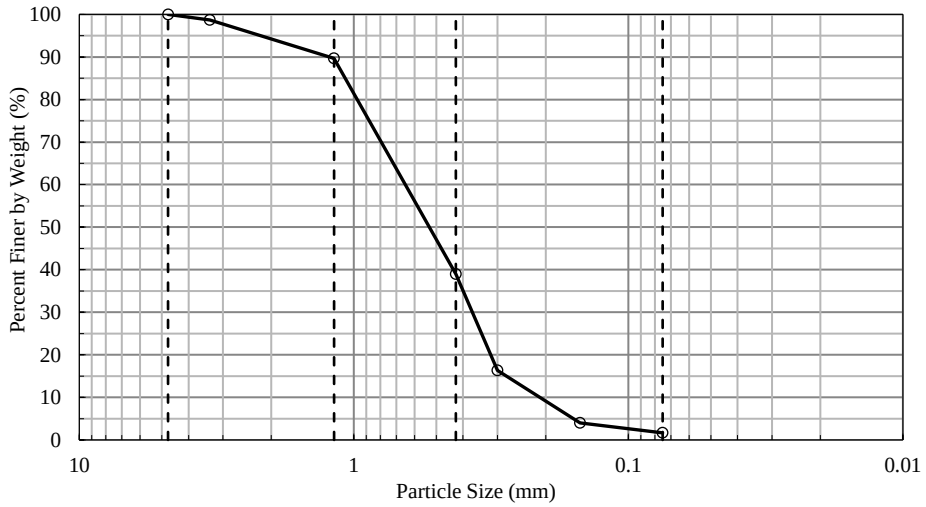

Figure 2: The particle size analysis of alum sludge

Slump test

Figure 3 represents the comprehensive analyses of slump test results provides valuable insights into the influence of alum sludge replacement on concrete workability. The findings reveal that a 100 % substitution of alum sludge leads to a significant decrease in slump, with recorded values ranging from 0 to 4 mm, indicating extremely poor workability. This highlights the challenges associated with entirely replacing sand with alum sludge in concrete mixtures.

However, as the replacement rate increases to 15%, the slump begins to low because cohesion of alum sludge. This reduction is attributed to the physical and chemical properties of alum sludge exceeding the optimal water/cement ratio, resulting in decreased workability. The observed slump test results Table 3, ranging from 30 mm (0% replacement) to 40 mm (15% replacement), offer valuable insights into the relationship between alum sludge replacement and concrete workability. While complete replacement negatively impacts workability, partial replacement initially improves it before reaching a threshold beyond which workability diminishes.

Table 3: The results of slump test

Control mix	30mm
5% alum	35mm
10% alum	50mm
15% alum	40mm

Figure 3: The slump test of different percentages of alum sludge

Compaction factor test

The compaction factor test as shown in Figure 4 plays a pivotal role in assessing concrete workability, shedding light on how easily freshly mixed concrete can be compacted. Results from the test are categorized as high, moderate or low compaction factors, providing valuable insights. The interpretation of these results is crucial for refining concrete mixes to meet specific project requirements. Striking a balance between workability and strength is essential for the successful execution of concrete construction projects, ensuring both durability and structural integrity. Adjustments to mix proportions, additives or the overall mix design process may be contemplated based on the observed compaction factor.

In Table 4, the compaction factor test results reveal that the 10% and 15% replacements exhibit a high compaction factor. This signifies excellent workability, suggesting easy placement and compaction. Additionally, it is noteworthy that such mixes are suitable for intricate shapes and structures, promising a smooth surface finish and efficient construction practices. These findings underscore the significance of the compaction factor in guiding decisions regarding concrete mix optimization for superior performance in construction projects.

Figure 4: Compaction factor test

Table 4: The results of compaction factor test

Control mix	0.84	Low
5% alum	0.90	Medium
10% alum	0.93	High
15% alum	0.96	High

Compressive Strength Test

In Figure 5, the compressive strength of all concrete mixes exhibits a consistent upward trend concerning curing age. Specifically as shown in Figure 6, at a 5% partial replacement of sand, the compressive strength of the concrete specimens reached 20 MPa, 25.45 MPa and 27.18 MPa after 7 days, 14 days and 28 days of curing, respectively.

However, a contrasting trend is observed at 15 % replacement, where the compressive strength is notably lower compared to the earlier results. The decline in strength at 15 % replacement of alum sludge is likely attributed to a potential deterioration in bond between particles. As the percentage of alum sludge replacement increases, the surface area of contact between alum sludge grows. Despite the constant sand content in the concrete, the additional bonding required is lacking, leading to a reduction in compressive strength.

Remarkably, at a 15 % replacement rate, a significant enhancement in compressive strength is evident. This suggests that this particular replacement percentage fosters a favorable balance between the surface texture of particles and the bonding with cement paste, resulting in improved compressive strength.

Figure 5: Compressive strength test

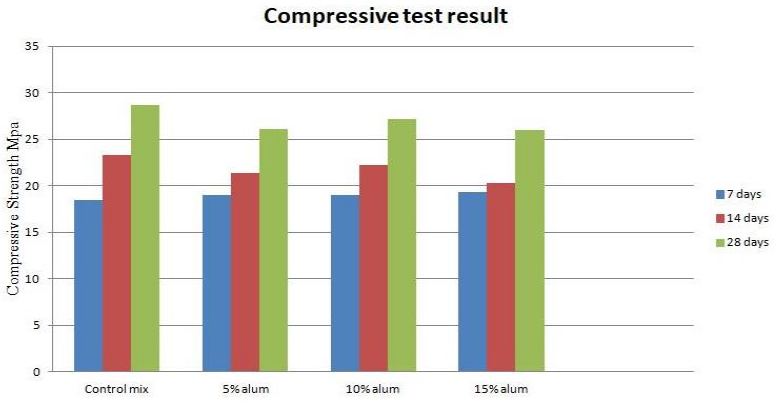

Figure 6: The compressive strength test result.

Flexural strength test

The flexural strength assessment of hardened concrete test specimens will involve applying a constant moment in the central zone while loading at two (or three) points. Upon extraction from water, specimens will be promptly analyzed while still wet. The test begins by precisely centering the specimen's longitudinal axis within the apparatus. In the case of molded specimens, the loading direction must be perpendicular to the direction of mold filling. Load application commences only after ensuring that all supporting and loading rollers are uniformly in contact with the test specimen as shown in Figure 7. For high-strength concretes, higher loading rates will be applied, while lower loading rates will be used for concretes with lower strengths. Once the loading rate is set, it should be maintained until failure occurs. The breaking load, signifying the maximum weight recorded on the scale at the point of failure, is then determined.

Test results outlined in Figure 8, revealed that the flexural strength values of concrete incorporating alum sludge exhibit a notable deterioration ranging from 5 % to 15 % when compared to the control concrete. Specifically, at a 5 % partial replacement of alum sludge, the flexural strength was measured at 2 MPa, 2.2 MPa and 2.7 MPa after 7, 14 and 28 days, respectively. This signifies a significant decrease of 15 % in flexural strength compared to the control mix.

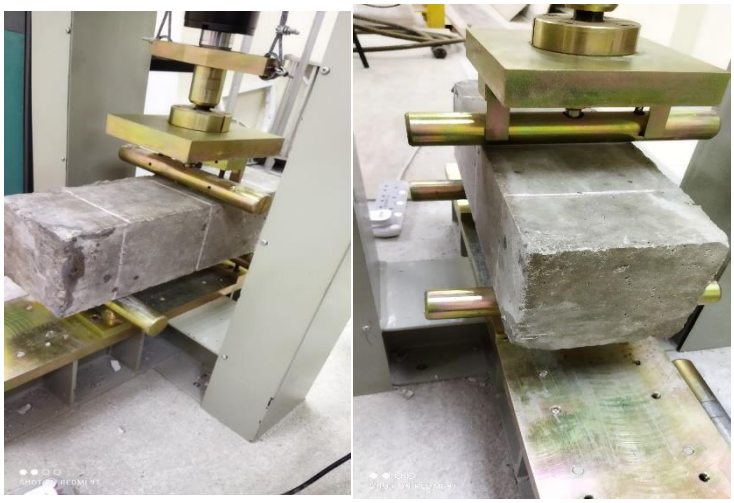

Figure 7: Arrangement of two-point loading.

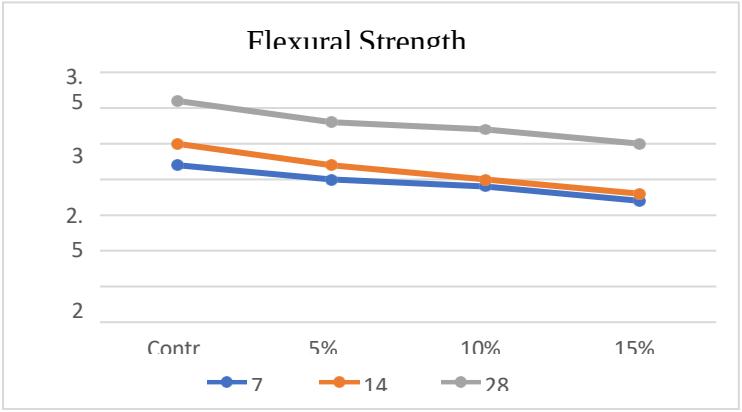

Figure 8: Flexural strength test result.

CONCLUSION

The purpose of this research is to explore the characteristics of concrete incorporating oven-dried alum sludge as a partial substitute for fine aggregate. The outcomes of this investigation conclude that the inclusion of alum sludge enhances the properties of concrete when used as a replacement for fine aggregate. The overarching goal of this study was to assess the viability of alum sludge as a partial substitute for sand in concrete mixtures. The research encompassed the formulation of concrete mixes containing alum sludge and the evaluation of concrete properties in both the fresh and hardened states. The properties under examination included mix workability, compressive strength and flexural strength. The study highlights the complex interplay between alum sludge replacement and concrete performance. While partial replacement of alum sludge shows promise in enhancing workability and even compressive strength up to a certain threshold, there are diminishing returns beyond this point.

Additionally, the flexural strength of concrete decreases with increasing alum sludge content. These findings underscore the importance of carefully balancing sustainability objectives with concrete performance requirements. A nuanced approach to alum sludge utilization is necessary, considering factors such as workability, strength, and overall performance. Future research should focus on optimizing alum sludge incorporation in concrete mixtures to maximize sustainability benefits while maintaining structural integrity and durability. Overall, this study contributes valuable insights into the potential of alum sludge as a partial replacement for sand in concrete mixes, guiding sustainable practices in the construction industry.

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RED MUD AS A CEMENT PARTIAL REPLACEMENT IN CONCRETE ADMIXTURE WITH HYDRATED LIME

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ABSTRACT

Red mud is a solid waste formed in the alumina sector that provides a substantial environmental risk as well as a storage issue. In this study, an attempt is made to partially replace cement in concrete with red mud in various percentages to reduce the harmful effects of red mud and cement on the environment. Hydrated lime is also added to assist the red mud in achieving pozzolanic properties. The suitability of red mud with hydrated lime as a partial replacement for cement in concrete admixture was investigated. The mechanical properties of concrete admixture with the addition of red mud and hydrated lime as a partial replacement for cement were analyzed. Efforts were also made to determine the optimum percentage of red mud and hydrated lime in a concrete mixture. The results showed that adding red mud with hydrated lime as a partial replacement to concrete mixtures boosted the workability, strength, durability, and general performance of concrete in all varying percentages, with the exception of those where the red mud replacement was equal to 5% and a percentage of either 5% or 7% hydrated lime. The results also revealed that the highest compressive strength value obtained was 30.24 MPa with a 10% red mud and hydrated lime replacement at 7% and 28 days of curing age. The study concluded that the properties of the concrete were enhanced by using varying red mud percentages of 5%, 10% and 15%; and a fixed rate of hydrated lime at 7% and 5%. This will lower the cost of producing concrete by utilizing a waste product, thereby promoting recycling efforts as the main strategy for mitigating the overwhelming impact of massive waste volumes on the environment.

Keywords:
Red mud, Hydrated lime, compressive strength, concrete mixture, optimum percentage

INTRODUCTION

Concrete is one of the most commonly utilized materials in the construction industry and a variety of civil engineering works. Concrete is mainly composed of aggregates, water, and cement. A chemical reaction occurs when cement mixes with water to produce a gel or paste covering the aggregates and binds them together. This process causes the concrete to harden. Hardening in concrete typically occurs in a few hours; although it takes weeks for concrete to fully harden and sometimes, even longer to reach its full-strength potential. Due to the concrete's impressive sturdiness, moldability, versatility, ease of access in every locale in the world, and its relatively cheap production cost, it has been historically the most popular option for construction all over the globe. Concrete also possesses high fire resistance, high water resistance, and high wind resistance. It is excellent for sound and vibration isolation, and it has unmatched longevity. It is a construction material that never rots, burns, or rust. However, due to the rapid global industrialization of today's market, concrete has been in demand more than ever in recent history. This massive surge in demand causes a few problems in the environment due to the cement's tendency to generate carbon dioxide, a potent greenhouse gas (K. Viyasun, 2020). Furthermore, due to inflation in today's market and other factors, cement is more expensive to produce than ever.

Concrete's global usage has led researchers to explore and experiment with its properties by adding different materials such as waste and recycled materials as admixtures. One such material is red mud. (Mr. P. Ajay Kumar, 2017) Red mud is a waste material generated in the aluminum industry during the extraction of alumina from bauxite through the Bayer process. Due to red mud's sheer abundance, toxic nature, and difficulty to dispose of or recycle effectively, it has been declared that

red mud is causing significant harm to the environment (W.C. Tang & Z. Wang, 2018). Despite that, red mud provides many advantages as a partial replacement for cement in concrete (Bavani, 2018). In most cases, red mud is reported to help increase concrete's compressive and tensile strength, especially when paired with hydrated lime. It is also reported that the red mud improves the workability of the concrete. In addition, using red mud helps reduce the production cost of concrete as well as improves the impact absorption ability of the concrete. Red mud also helps prevent the corrosion of reinforcement and acts as an excellent binding material. Red mud is a good waste material that can benefit the construction industry.

In this research study, an attempt was made to solve both cement and red mud problems by reducing cement demand and recycling red mud by utilizing it as a partial replacement for cement in concrete, with hydrated lime to assist red mud in achieving Pozzolanic properties. The study thus also focuses on the addition of the lime as an additive that will improve the strengthening outcomes.

METHODOLOGY

In this section, the processes and methods needed to successfully carry out the objective of this research study are explained: processes such as examining the effects of red mud (Figure 1) with hydrated lime (Figure 2) as a partial replacement for cement in concrete, explaining the materials needed and the methods involved, laboratory activities required, sampling and replacement percentages details, and experiments that were performed. The experiments conducted were the slump test and the compressive strength test. All the experiments were conducted in the Infrastructure University Kuala Lumpur's civil engineering laboratory. The replacement percentages for red mud as a partial replacement for cement in concrete were 0%, 5%, 10%, 15%, with a fixed rate of hydrated lime at 7% and 5%. The cube sample size was 100mm x 100mm x 100mm, which was used for the compressive strength test.

Figure 1: Sintering Red Mud

Figure 2: Hydrated lime

Slump Test

As stated by Pateliya (2017), it is crucial for concrete to have sufficient workability to assist in removing entrapped air by acquiring minimum compaction. The slump test is by far the simplest and most widely used test to test the workability of fresh concrete. The concrete slump test is conducted from batch to batch to check the concrete's uniform consistency during construction

Curing Process

Concrete curing is the method of securing sufficient moisture in concrete within an acceptable temperature range in order to help cement hydration at early ages. Hydration is the chemical reaction between water and cement that ends in the formation of various chemicals contributing to setting and hardening. The hydration process is influenced by the initial concrete temperature, the ambient air temperature, the dimensions of the concrete, and the mix design

Compressive Strength Test

The compressive strength test is regarded as one of the most common tests conducted on concrete in the construction industry. It gives a comprehensive idea of all the properties of the concrete sample. This test is the deciding factor on whether the concrete sample will get accepted or rejected. Compressive strength as a concrete trait relies on various constituents associated with the quality of the adopted materials, mix design, and quality control through concrete manufacturing. The compressive strength of concrete is fundamentally the ability of the concrete to resist axial force. The more compressive strength the concrete poses, the more axial load it can bear before fracturing. The compressive strength test is designed to examine the compressive strength of a concrete sample by gradually applying load on the sample until it fails, and the reading of compressive strength is taken at the point of failure using a compressive testing machine. For this research study, 42 cubes were cast with a size of 100mm x 100mm x 100mm for a curing period of 7 and 28 days. To conduct the compressive strength test, concrete was poured into a mold and appropriately compacted to reduce the number of voids in the mix. After 24 hours, molds were removed, and test specimens were then stored in water for curing. After the specified curing period, specimens were tested by the compressive testing machine. Load was applied gradually until specimen failure. The load of failure was divided by the cross-sectional area of the sample to get the compressive strength of the concrete. The test was carried out in accordance with BS EN 12390-3 (2009). Figure 3 depicts the flow of the processes

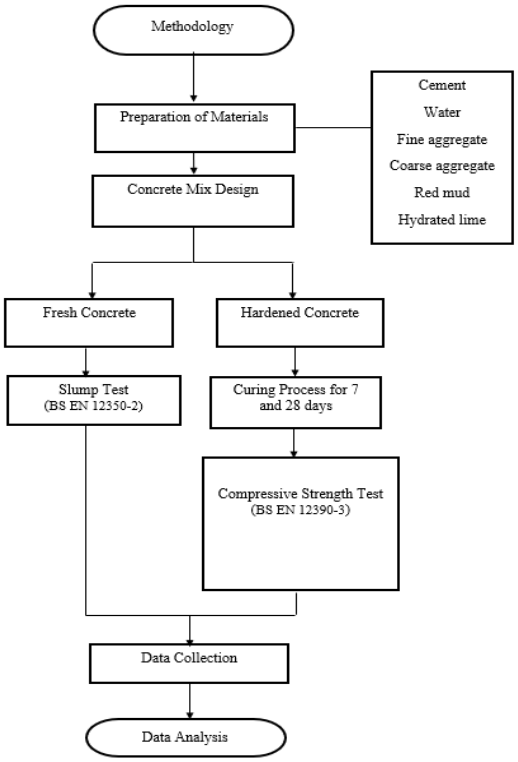

Figure 3: Research Flow Chart

RESULT AND DISCUSSION

The data analysis and results are covered in this section to demonstrate a thorough comprehension of the study. In this study, two different types of concrete were made. The first was a standard mix, and the second was a combination of red mud and hydrated lime in varying proportions. The purpose of this study is to present, analyze, and contrast the conventional concrete's test findings with those of concrete created from red mud and hydrated lime. The concrete cubes with varying red mud percentages (0%, 5%, 10%, 15%) and a fixed rate of hydrated lime at 7% and 5% produced the results shown below. The experiments were conducted along with slump tests to determine whether the addition of red mud and hydrated lime concrete was workable. The cubes, which measure 100 x 100 x 100 mm, were put to the test at the ages of 7 and 28 days. All of the tests that were run followed the procedures outlined in the preceding section. Table 1 contains the details of the experiments.

Table 1: Total Concrete Cubes for Compressive Strength Test

No of Samples.	**Cement percentage**	**Red mud %**	**Hydrated Lime %**	**Number of cubes**	
				7 days	**28 days**
CS	100%	0%	0%	3	3
S1	88%	5%	7%	3	3
S2	83%	10%	7%	3	3
S3	78%	15%	7%	3	3
S4	90%	5%	5%	3	3
S5	85%	10%	5%	3	3
S6	80%	15%	5%	3	3
	Total no.			42	

Sieve Analysis for Coarse and Fine Aggregate

The sieve analysis was carried out in accordance with the British Standard (BS) for fine aggregates (sand) and coarse aggregates (stones with a maximum size of 20mm). The goal of this test was to create well-graded fine and coarse aggregates with maximum packing, which increased the toughened characteristics. Tables 2 and 3 indicate the aggregate mix proportion from various sieve sizes

Table 2**:** Coarse Aggregate (Stone Chips)

Sieve size(mm)	**Weight retained (gm)**	**% of weight retained**	**Cumulative % wt. retained**
20	581	14.53%	14.53%
16	1338	33.45%	47.98%
12.5	994	24.85%	72.83%
10	670	16.75%	89.58%
4.75	387	9.68%	99.25%
Pan	30	0.75%	100.00%
Sum	4000	100.00%	424.15%

Table 3**:** Fine Aggregate (Coarse Sand)

Sieve size(mm)	**Weight retained (gm)**	**% of weight retained**	**Cumulative % wt. retained**
4.75	245	8.17%	8.17%
2.36	176	5.87%	14.03%
1.18	389	12.97%	27.00%
0.6	1056	35.20%	62.20%
0.3	123	4.10%	66.30%
0.15	979	32.63%	98.93%
Pan	32	1.07%	100.00%
Sum	3000	100.00%	376.63%

Following data computation, it was discovered that aggregate's fineness modulus (FM) was 8.00, indicating that the test concluded that stone chips would be suitable for construction.

$$\text{FM (Fineness modulus)} = \frac{\sum \%\ \text{Cumulative Wt. retained}}{100}$$

$$= \frac{(424.15+376.63)}{100}$$

$$= 8.00$$

Slump Test

When red mud replacement percentage was increased, the slump value rose in S1, S2, and S3 with red mud percentages of (5%, 10%, and 15%) and a fixed rate of hydrated lime at 7% (See Table 1 for the details of combinations). With red mud replacement percentages of (5%, 10%, and 15%) and a fixed rate of hydrated lime at 5%, a similar observation was made in S4, S5, and S6; as red mud replacement percentage rises, slump value rises. Additionally, it can be inferred that S3, which contained 15% red mud and 7% hydrated lime, had the largest slump value and hence the highest workability of fresh concrete. Due to its finer particles, larger volume, and slightly lower weight, red mud actually has a lower flow property since it requires more water to be absorbed (Chavan et al., 2021). The slump value for the control sample was 22 mm, while the slump values for the samples with replacements of red mud at 5%, 10%, and 15% and a fixed rate of hydrated lime at 7% were 18 mm, 29 mm, and 39 mm respectively. Additionally, the slump values obtained are 16 mm, 26 mm, and 36 mm, respectively, when replacing red mud with percentages of 5%, 10%, and 15% with a fixed rate of hydrated lime at 5%. Figure 4 depicts the results in a graphical format. The results lead to the conclusion that fresh concert is more workable the more the combination of red mud and hydrated lime is added.

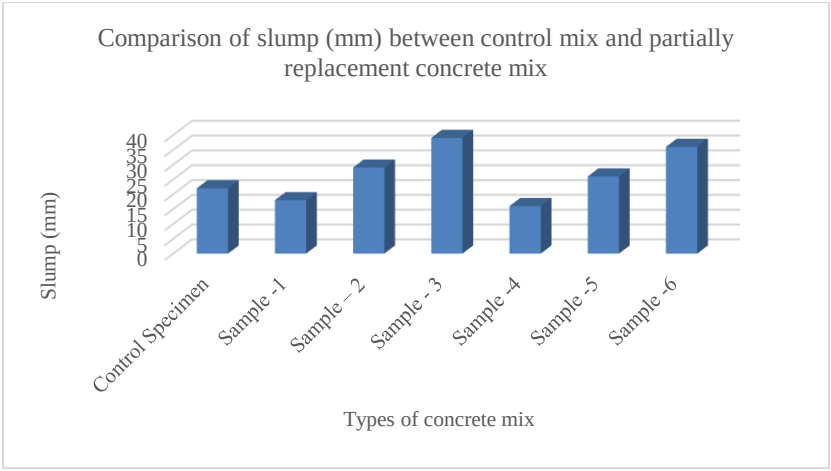

Figure 4: Slump Test Results

Compressive Strength Test

The primary goal of this study is to investigate the compressive strength of concrete having varying amounts of red mud (0%, 5%, 10%, and 15%) and a fixed amount of hydrated lime (7% and 5%), and to compare it to the compressive strength of the control sample. Before being taken out of the curing tank for testing on compressive strength, the concrete samples were cured for periods of 7 and 28 days. In this study, a total of 42 100mm x 100mm x 100mm concrete cubes were evaluated (21 cubes for both 7 and 28 days).

7-Day Curing Age

Since concrete obtains 65% of the desired strength after 7 days of casting, concrete specimens were evaluated at 7 days after curing. Testing the concrete on day 7 is crucial because the results of the compressive strength test may be used to anticipate the final strength and ascertain whether the cube reaches the desired strength by displaying the trend of the concrete's strength. Table 4 contains the findings from the compressive strength test for the 7th day curing age while Figure 5 is the graphical depiction.

Table 4: Compressive Strength Test Result (7 days)

7 Days Curing						
Sample Name	**Replacement Percent**		**Specimens**			**Average of the Specimens**
	Red Mud	**Hydrate lime**	**S – 1**	**S – 2**	**S – 3**	
Control Specimen	0	0	18.41	16.47	18.31	17.73
Sample -1	5	7	20.81	20.60	19.69	20.37
Sample – 2	10	7	20.83	23.33	22.67	22.28
Sample - 3	15	7	19.47	19.35	19.53	19.45
Sample -4	5	5	20.49	20.38	19.97	20.28
Sample -5	10	5	21.37	21.61	21.40	21.46
Sample -6	15	5	18.19	18.84	19.45	18.83

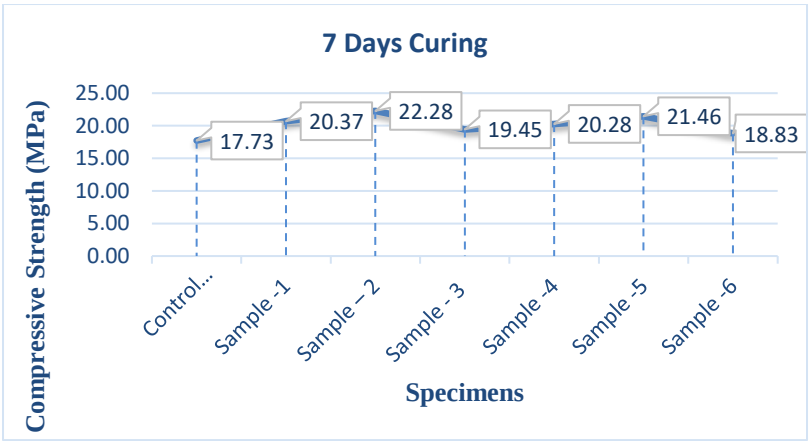

Figure 5: Average compressive strength of concrete at 7 days of curing age

The control sample that contains 0% of red mud and hydrated lime gave a compressive strength of 17.73 MPa. On the other hand, Samples 1, 2 and 3, containing a mix of red mud of 5%, 10%, and 15%, and a fixed rate of hydrated lime at 7%, achieved a compressive strength of 20.37 MPa, 22.28 MPa and 19.45 MPa respectively. As a result, red mud at 10% and a fixed rate of hydrated lime at 7% yields concrete with the maximum compressive strength, 22.28 MPa, which is within the range of what has been calculated. According to Bhardwaj and Gupta (2019), the seven-day compressive strength should vary between 19 and 22.35 MPa. In addition, the compressive strength test results for 4, 5 and 6 which contained red mud of 5%, 10%, and 15%, and a fixed rate of hydrated lime at 5% gave 20.28 MPa, 21.46 MPa and 18.83 MPa respectively. This shows that with 10% of red mud and 5% of hydrated lime, the maximum compressive strength was obtained at 21.46 MPa. These findings are consistent with the compressive strength data obtained by Bhardwaj and Gupta (2019) for 5%, 10%, and 15% red mud, which were 22.5, 21.3, and 19.7 MPa respectively, after 7 days of curing. Furthermore, the specimen containing 10% of red mud and 7% of hydrated lime achieved the highest compressive strength out of all 6 average compressive strength at 7 days of curing age giving 22.28 MPa.

28-Day Curing Age

In addition to being tested after 7 days of curing, specimens of concrete were also tested after 28 days, when 99% of its strength had been attained. Testing the concrete on Day 28 is crucial to determining whether the concrete cube reaches the desired strength. Table 6 contains the findings of the compressive strength test for 28-day curing age while Figure 5 is the graphical depiction.

Table 5: Compressive Strength Test Result (28 days)

28 Days Curing						
Sample Name	**Replacement %**		**Specimens**			**Average of the Specimens**
	Red Mud	**Hydrated lime**	**S – 1**	**S – 2**	**S – 3**	
Control Specimen	0	0	25.08	25.53	24.42	25.01
Sample -1	5	7	26.81	26.73	26.24	26.59
Sample – 2	10	7	29.66	30.51	30.54	30.24
Sample - 3	15	7	24.87	24.84	25.64	25.12
Sample -4	5	5	26.67	27.81	24.31	26.26
Sample -5	10	5	29.08	29.13	27.90	28.70
Sample -6	15	5	24.38	24.59	25.25	24.74

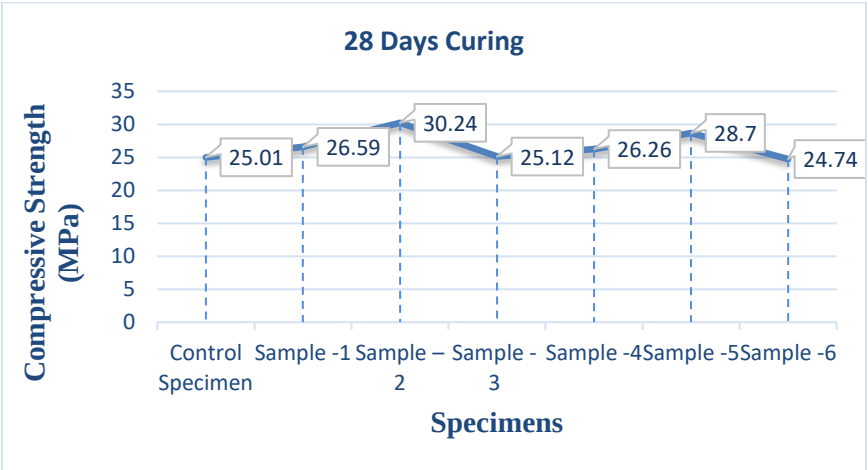

Figure 6: Average compressive strength of concrete at 28 days of curing age

The control sample which contains 0% of red mud and hydrated lime gave a compressive strength of 25.01 MPa. On the other hand, Specimens 1, 2 and 3 containing a mix of red mud of 5%, 10%, and 15%); and a fixed rate of hydrated lime at 7% achieved a compressive strength of 26.59 MPa, 30.24 MPa and 25.12 MPa respectively. As a result, red mud at 10% and a fixed rate of hydrated lime at 7% yields concrete with the maximum compressive strength of 30.24 MPa. In addition, the compressive strength test results for specimens 4, 5 and 6 which contained red mud of 5%, 10%, and 15% and a fixed rate of hydrated lime at 5% gave 26.26 MPa, 28.70 MPa and 24.74 MPa respectively. This corresponds to the range calculated by Cholkar et al. (2021) where the twenty-eight-day compressive strength varied from 27 to 31.8 MPa, and that with 10% of red mud and 5% of hydrated lime, the maximum compressive strength was obtained at 28.70 MPa. Furthermore, the specimen containing 10% red mud and 7% hydrated lime achieved the highest compressive strength out of all 7 average compressive strengths at 28 days of curing age giving 30.24 MPa. Lastly, the highest compressive strength of concrete achieved at 7 days and 28 days of curing age for cubes with varying red mud percentages at 0%, 5%, 10%, 15% and a fixed rate of hydrated lime at 7% and 5% was 30.24 MPa with 10% red mud and hydrated lime at 7%, whereas the lowest was achieved with 0% of red mud and hydrated lime and 7 days of curing age, giving only 17.73 MPa.

The Effect of Red Mud on the Compressive Strength of Concrete

Based on an analysis of the results, utilizing red mud with cement paste has increased and decreased their compressive strengths. The main ingredients in red mud that contribute to its pozzolanic activity are alumina and reactive silica (Kang et al., 2020). These reactive substances have the ability to react chemically with calcium hydroxide to produce products of secondary hydration. The concrete microstructure's voids are filled in part by the pozzolanic process. The concrete's mechanical qualities are enhanced by this filling action, which creates a denser and more compact matrix. The red mud concrete's compressive strength values were higher than those of the control sample for both the 5 and 10 percent replacement percentages. This is because the red mud accelerates the pozzolanic reaction between cementitious materials (cement and red mud), which increases the compressive strength values. It also strengthens the bond between the cement and aggregate through a slight pozzolanic reaction and the matrix-filling effect of fine red mud particles. Nevertheless, a strength reduction was noted when the replacement reached 15%; this reduction was not, however, smaller than in the control sample. The reason for this reduction is that the higher replacement content of red mud led to insufficient cement hydration through the filler and internal curing effects of red mud. Between the red mud and the other minerals in the concrete, there was not enough pozzolanic reaction. The result was a decrease in the development of calcium silicate hydrate (C-S-H) gel. This explains why, following the 10% mix, all mechanical qualities were drastically reduced.

CONCLUSION

This investigation was methodically carried out to assess the viability and possible advantages of utilizing red mud and hydrated lime as partial substitutes for cement in concrete admixtures. Based on thorough analyses, it was concluded that this combination has promising features that could make it useful in concrete applications. Furthermore, the experiments in adding red mud and hydrated lime provided important information about the workability, strength, durability, and general performance of the material. These results greatly advance knowledge of how the added elements affect the mechanical properties of the concrete. Previous experiments demonstrated that adding red mud with hydrated lime as a partial replacement to concrete mixtures boosted the workability of concrete in all varying percentages, with the exception of those where red mud replacement was equal to 5% and a percentage of either 5% or 7% hydrated lime. Additionally, the results showed greater values compared to the control sample when varied red mud percentages of 5%, 10%, and 15% and a set rate of hydrated lime at 7% and 5% were used as a partial replacement for cement in concrete admixture. The results also revealed that the highest compressive strength value obtained was 30.24 MPa with a 10% red mud and hydrated lime replacement at 7% and 28 days of curing age, confirming the hypothesis of improving concrete mechanical properties such as compressive strength and workability. The study concluded that the properties of the concrete were enhanced by using varying red mud percentages 5%, 10%, and 15% and a fixed rate of hydrated lime at 7% and 5%.

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ADAPTABILITY ANALYSIS OF CLOUD ENVIRONMENT AND LOAD PREDICTION ALGORITHM

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ABSTRACT

In the current cloud environment, resource scheduling is an important research field aimed at effectively managing and allocating cloud computing resources to meet user needs and optimize system performance (Yu, 2021). However, resource scheduling and load prediction are two closely related concepts that influence and depend on each other in the cloud environment (Kumar & Sharma, 2020). Load prediction provides an important reference for resource scheduling (Niri et al., 2020; L. Zhang et al., 2021a). By accurately predicting the load situation, resources can be allocated and adjusted in advance before load fluctuations occur, avoiding problems of resource shortage or waste. At the same time, load prediction can also help resource scheduling algorithms better understand load patterns and trends, thereby formulating more reasonable scheduling strategies. It can be said that to a certain extent, load prediction is the basis for resource scheduling. How to carry out precise load prediction has become a typical challenge faced by current research on cloud computing scheduling optimization. This paper first analyses the characteristics of the cloud environment and finds that there are problems such as increasingly obvious dynamic load characteristics, diversified resource requirements, and poor reliability of workflow task execution (Saif et al., 2021; Zhou et al., 2020). Then, starting from the dynamic characteristics of the cloud environment, this paper summarizes and analyzes its impact on cloud resource scheduling (Cao et al., 2022; Peng et al., 2020), and outlines the limitations of traditional load prediction methods (Sideratos et al., 2020; L. Zhang et al., 2021b)in view of the non-stable characteristics of dynamic changes in resource utilization in the cloud environment. The contribution of this paper is to propose a decomposition-prediction algorithm that reduces the impact of the above uncertainties on scheduling by predicting the host load.

Keywords:
Cloud environment, dynamic load characteristics, resource scheduling, load prediction methods, prediction algorithm

INTRODUCTION

Cloud computing, as a new computing model and service category, provides flexible demand allocation, scalable computing services, and elastic resource scheduling for enterprises and users through virtualization, distributed computing, and dynamic scheduling technologies (Bello et al., 2021). It effectively solves problems such as uneven resource sharing (Barrouillet et al., 2007) and low storage efficiency (Abdalla et al., 2022; Nannai John & Mirnalinee, 2020), greatly improving the availability of computing resources. More and more users choose to migrate their applications or data to the cloud to accept its computing or storage services. As the physical carrier of cloud computing, the scale of cloud data centers is expanding (Gao et al., 2022), making the load dynamics of the cloud environment obvious (J. Chen et al., 2023; Rani & Geetha Kumari, 2021).

Load prediction is the process of predicting and estimating the load situation in a future period of time (Fatin et al., 2022; Saripalli et al., 2011; Singh et al., 2021). This makes load prediction that conforms to the characteristics of cloud computing particularly important. Reviewing traditional load prediction algorithms, Moving Average (Schaffer et al., 2021), Exponential Weighted Moving Average (Sukparungsee Id et al., 2020), Autoregressive Moving Average (Prado et al., 2020), and Neural Networks (Chicco, 2021; Gawlikowski Student Member et al., 2021; Li et al., 2022) all have

a strong dependence on historical data, which does not fit well with the dynamic load of the cloud environment.

Therefore, this study uses Multiple Prediction Combination Methods to overcome the limitations of traditional methods. It is expected that the method proposed in this study will be better adapted to the characteristics of cloud computing. This paper mainly introduces the research topic, research motivation, problem statement, and conclusion.

RESEARCH MOTIVATION

The motivation for this study lies in the continuous development of cloud computing technology, which has higher requirements for the adaptability of load prediction methods.

Moving Average is a simple and commonly used real-time load prediction algorithm (Prado et al., 2020). It predicts future loads based on the average value of historical load data. The moving average algorithm is simple to use, has low computational complexity and real-time performance, and is suitable for stationary or slowly changing load situations. However, the moving average algorithm has poor adaptability to rapidly changing and nonlinear load patterns.

Exponential Weighted Moving Average (EWMA) is a real-time load prediction algorithm based on exponential weighting (Nyamasvisva et al., 2022; Sukparungsee Id et al., 2020). It performs a weighted average of historical load data, with newer data having higher weights. The EWMA algorithm can adapt to changes in load more quickly and has a certain degree of real-time performance and accuracy. However, the EWMA algorithm is sensitive to sudden changes or abnormal data in the load, which may cause error accumulation.

The Autoregressive Moving Average (ARMA) model combines the characteristics of autoregression (AR) and moving average (MA) for real-time load prediction (Schaffer et al., 2021). The ARMA model considers the historical data and error terms of the load, and predicts future loads through parameter estimation and model fitting. The ARMA model is suitable for load data with certain autocorrelation and trends. However, the parameter estimation and model fitting of the ARMA model are relatively complex and need to be adjusted and optimized according to specific situations.

Neural network models are also widely used in real-time load prediction (Chicco, 2021; Li et al., 2022). Among them, recurrent neural networks (RNN) and long short-term memory networks (LSTM) are common models. These models can capture the temporal characteristics and complex relationships of load data, and have strong nonlinear modeling capabilities. Neural network models can achieve relatively accurate real-time load prediction, but require a large amount of training data and computational resources, and the adjustment of hyperparameters and model optimization are relatively complex.

The Kalman filter algorithm has the advantages of efficiency and accuracy, making it suitable for state estimation and prediction in dynamic systems (Khodarahmi, et al., 2022). It can also be combined with other algorithms for applications in emerging fields like cloud computing. However, the algorithm relies on linear assumptions and noise models, with its performance being significantly affected by initial conditions and parameter settings. Additionally, the computational cost cannot be ignored when dealing with large-scale complex systems. Therefore, it is essential to leverage its strengths and address its weaknesses by optimizing algorithm parameters and models to enhance its effectiveness in specific application scenarios.

From Table 1, it can be observed that the moving average method is simple and easy to use, suitable for stable loads, but weak in adapting to rapid changes. The Exponentially Weighted Moving Average (EWMA) responds quickly to load changes, but is sensitive to abrupt data and tends to accumulate errors. The Autoregressive Moving Average (ARMA) model is suitable for autocorrelated loads, but parameter fitting is complex. Neural network models, such as RNN and LSTM, can

precisely capture complex load relationships, but have high training costs and complex optimization. Therefore, the Kalman filter algorithm aligns well with the characteristics of cloud environments.

Table 1: SWOT Analysis of Existing Load Prediction Algorithms

	Algorithm	Strengths	Weaknesses	Opportunities	Threats
1	Moving Average (MA) (Prado et al., 2020)	Based on the average of historical load data to predict future load, easy to use, fast calculation	Poor adaptability to rapid changes and nonlinear load patterns	Suitable for flat or slowly changing loads	Poor adaptability to dynamic data
2	Exponential Weighted Moving Average，（EWMA) (Nyamasvisva et al., 2022; Sukparungsee Id et al., 2020)	The weighted average of historical load data, the more recent data has a higher weight, with a certain real time and accuracy.	More sensitive to load mutations or abnormal data	Able to adapt to changes in load faster	It may result in accumulation of errors.
3	Autoregressive Moving Average，（ARMA） (Schaffer et al., 2021)	Taking into account the historical data and errors of loads and predicting future loads through parameter estimates and models.	Parameter estimates and model adaptation are more complex	Applicable to load data with a certain relevance and trend	Need to be adjusted and optimized according to specific load conditions
4	Neural Networks (NN) (Chicco, 2021; Li et al., 2022)	Able to capture timing characteristics and complex relationships of load data	It requires a lot of training data and computational resources	Strong non-linear modelling capabilities	Adjustment and model optimization for super-parameters are more complex
5	Kalman Filter Algorithm (Khodarahmi, et al., 2022)；	Has the advantages of efficiency and accuracy	The algorithm relies on linear assumptions and noise models	Can be combined with other algorithms for applications in emerging fields like cloud computing	The computational cost cannot be ignored when dealing with large-scale complex systems

STATEMENT OF THE PROBLEM – Load Prediction Algorithm

Many scholars have pointed out that due to the high scalability and flexibility of cloud computing, it has received increasing attention, and cloud services supported by it have become a new IT service model (Javadpour et al., 2022; Mapetu et al., 2021; Zhu et al., 2019). More and more users choose to migrate applications or data to the cloud to accept its computing or storage services. The scale of cloud data centers, as the physical carrier of cloud computing, is expanding, making the load dynamics in the cloud environment obvious.

Other scholars pointed out that workload prediction algorithms based on statistical methods lack adaptability to highly variable workloads (Y. Chen et al., 2020; Gao et al., 2020). In addition, some scholars also pointed out that workload prediction algorithms based on classical machine learning require manual feature extraction and model parameter adjustment, which is both difficult and time-consuming (Gao et al., 2020; Zhu et al., 2019). Additionally, scholars pointed out that workload prediction algorithms based on deep learning do not require manual feature extraction, but their prediction accuracy is limited (Gao et al., 2020; Toumi et al., 2019).

There are also scholars who pointed out that neural network algorithms or linear regression methods cannot predict real loads with large fluctuations well (Toumi et al., 2019; Xu et al., 2022). Although the use of ensemble learning has a more accurate final learning effect, the nonlinear characteristics of the load sequence cannot achieve satisfactory real value prediction, and the prediction time is too long to predict real-time loads.

In summary, with the development of cloud computing and cloud data centers, the cloud environment is becoming more complex. Cloud environment workload prediction faces problems such as obvious dynamic characteristics of the load, low prediction accuracy, and poor real-time performance of prediction algorithms.

PROPOSAL

As described earlier, it is particularly important to propose a load forecasting algorithm that can better adapt to cloud environments. Therefore, this article proposes combining the Kalman filter algorithm with the EMD algorithm, aiming to better adapt to the characteristics of cloud environments.

The Kalman Filter Algorithm has good performance in linear system models and real-time application scenarios (Khodarahmi, et al., 2022). Through optimal estimation and recursive updating, it provides accurate state estimation and prediction results. It also has dynamic model adaptability and low computational complexity, and is suitable for many application fields that require real-time, accurate and efficient filtering.

The EMD algorithm has the advantages of adaptability, being data-driven, flexibility, no prior assumptions, and time locality. These characteristics make the EMD algorithm widely used in signal processing, vibration analysis, modal analysis, and other fields, providing more accurate, comprehensive, and reliable signal decomposition and feature extraction results (Quinn et al., 2021; Y. Zhang et al., 2022).

This study uses the prediction method of multiple prediction combination methods to propose a decomposition-prediction method. The schematic diagram is shown in Figure 1. By processing the original dynamic data through the EMD algorithm and then predicting the load through the Kalman Filter Algorithm, it aims to both adapt to the dynamic load characteristics of the cloud environment and ensure real-time prediction accuracy.

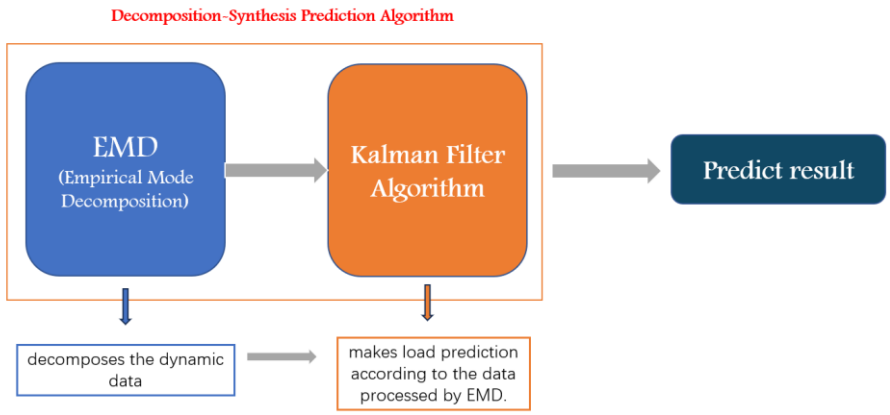

Figure 1: Decomposition-Synthesis Prediction Algorithm diagram.

CONCLUSION

This article analyzes the importance of load forecasting technology and the relationship between resource scheduling and load forecasting. It also identifies existing problems. The SWOT method is used to evaluate different load forecasting methods and analyze the advantages and disadvantages of algorithms. A solution is proposed: the prediction method of multiple prediction combination methods to propose a decomposition-prediction method.

A good load forecasting algorithm should be able to accurately and adaptively predict the future trend and pattern of load changes, while having scalability, robustness, interpretability, and comprehensive performance. Such an algorithm can provide strong support for resource scheduling and load balancing in a cloud environment, improving system performance and efficiency.

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A REVIEW OF A CURRENT RESEARCH ON THE BONDING PROPERTIES OF CONCRETE-FILLED STEEL TUBES

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ABSTRACT
This paper is presenting the theory and experimental results on the bonding performance of the concrete-filled steel tube (CFST) at global perspective. It is introducing the bonding mechanism of steel tube concrete with the overview of the updated status on the performance of it towards bond strength, analyzes and compares its main influencing factors methodologically. The data is gathered in the industrial usage and compared with the previous studies done by the previous researches to examine the real factors and characteristics with the bonding strength targeted. The results show that the width-thickness ratio is o of the main factors contributing to the bond strength. In general, width-to-thickness ratio is negatively correlated with the bond strength where the steel tube interface structure is helping the improvising of the bond strength. There is a negative correlation between the width-to-thickness ratio and bond strength. This paper is also highlights the pivotal role of structural configuration at the steel tube of the bond strength. There are main aspects that contribute to the bond strength such as concrete strength, concrete age, specimen dimension, slenderness ratio and other aspects. Further investigation needs to be carried out to consolidate existing information on the bonding strength and to understand the complexities involved in CFST bonding performance. In conclusion, this paper emphasizes the needs of research to be conducted to have deepen understanding and to enhance the practical applications of CFST technology and indirectly contributing to the advancements in structural engineering and construction technology applications. It is also an opportunity for researchers to investigate further the real potential of CFST technology in various branch of civil engineering.

Keywords:
Concrete-filled steel tube, bonding property, bonding mechanism, bond strength, structural engineering technology

INTRODUCTION

As a structural form with excellent performance, concrete-filled steel tube (CFST) is a combination structure composed of steel tube and concrete, which has the advantages of high bearing capacity, good seismic performance, good plastic toughness, low engineering cost and easy construction. It can well adapt to the development trend of modern building construction (Miss Basori Bano, 2023). It can meet the needs of the development of engineering structures to long span, tall and heavy loads and withstand harsh conditions. At present, it has been widely used in structural engineering such as industrial plant, high-rise building, bridge engineering, port engineering and underground engineering (Kong Linjie and Norul Wahida Kamaruzaman, 2023).

CFST is a state of synergy between steel tube and concrete. The concrete inside the steel tube is restricted by the outer steel tube, which delays the crack development and improves the compressive strength of the concrete under three-way compression. Concrete plays a supporting role on the steel tube, so that the defects of the steel tube structure are easy to bend are improved, and the stability of the steel tube is improved. The interface bond strength of steel tube and concrete is a key factor that affects the long-term working behavior of CFST structures and their collaborative work. However, in practical application, the effect of bond strength is often ignored or weakened. In addition, it is difficult to accurately measure the slip and interface stress before the interface in the

test process, and the test results are quite different. At present, the theoretical and experimental research of CFST structure is still controversial, and the theory and method are not perfect and unified.

CONCRETE FILLED STEEL TUBE BONDING MECHANISM

The interface shear bonding force of steel tube and concrete is similar to that of steel bar and concrete (Xue & Cai, 1996a, 1996b), which is mainly composed of three parts, namely, chemical bonding force, mechanical biting force and friction force.

(1) Chemical bonding force: The effect of chemical bonding force is small, and it has a greater relationship with the nature of concrete, such as the amount of cement, water-cement ratio, etc., have an impact on it. It was found that the chemical bonding force of CFST accounted for about 5% of the shear bonding force (Qu et al., 2013; Xue & Cai, 1996a).

(2) Mechanical biting force: the inner surface of the steel tube is often rough and uneven, and the degree of roughness is very small (Xue & Cai, 1996a), about 10-2 mm, which can be called "microscopic deviation". The mechanical bite force is generated by the microscopic deviation and the concrete wedged into it. When the inner surface of the steel tube is not oiled, the bonding strength of the specimen is twice that of the oiled specimen, while the bonding strength of the specimen after mechanical grinding and rust removal is only about 53% of that of the specimen without rust removal (Shakir-Khalil, 1993; Shakir-Khalil H, 1993).

(3) Friction: Unlike reinforced concrete, the expansion of core concrete will produce extrusion pressure at the interface, thereby increasing the interface friction, that is, the friction will change with the constraints of the steel tube and the stress stage. The friction force is closely related to the micro deviation, macro deviation and concrete deformation, and together with the mechanical bite force, it bears about 95% of the bonding stress (Xue & Cai, 1996b). Among them, (Virdi & Dowling, 1980) put forward the concept of "macro deviation", due to manufacturing process and other reasons, the diameter of the steel tube at different sections will always have a deviation, this macro deviation is difficult to accurately predict, which determines the size and development of interface friction to a certain extent.

RESEARCH STATUS OF CEMENTING PROPERTIES OF CONCRETE-FILLED STEEL TUBE

BONDING PROPERTIES OF CONCRETE-FILLED STEEL TUBE WITH DIFFERENT TYPES OF CONCRETE MATERIALS

With the development of society, continuous progress of science and technology and deepening of construction industrialization, the continuous development of new materials such as aggregate for concrete are diversified, such as recycled aggregate concrete, fiber concrete (Hou Zhicheng & Norhaiza Nordin, 2022), granite and Beranang laterite aggregate concrete (Norul Wahida et al., 2023). However, concrete made of different aggregates has different bonding and sliding properties.

BONDING PROPERTIES OF ORDINARY CFST

Pull out test of circular CFST has been carried out by (Virdi & Dowling, 1980), with concrete strength, interfacial bonding length, concrete age and interfacial treatment as the main parameters The pullout test of circular CFST was carried out, with concrete strength, interfacial bonding length, concrete age and interfacial treatment as the main parameters. The experimental results show that the concrete strength and interfacial bond length have less influence on the interfacial bond strength, and the

interfacial bond strength decreases with the prolongation of concrete age and the increase of lubricant. Another research conducted by (Morishita Y & Tomii M, 1979) in which the section type of steel tube and the strength of concrete were used as the research parameters to carry out the test of CFSTThe section type of steel tube and the strength of concrete were used as the research parameters to carry out the test of CFST. The experimental results reveal that the bond strength of CFST is significantly affected by the section type, and the bond strength of CFST with circular section is obviously higher than that with square section. (Shakir-Khalil H, 1993) tested 56 specimens and the main parameters included section type, shear connector type, loading method, etc. The results revealed that the interface bond strength of round steel tubular concrete was higher than that of rectangular CFST. The addition of shear connectors or welded supports will produce extrusion effect and construction effect, which can effectively improve the interface bond strength. (Roeder C W et al., 1999) studied 20 large size steel tube concrete specimens and the test reveals that the concrete strength of the bond strength of the influence of the law is not obvious; for the curing age of 28d specimens, its diameter and thickness ratio changes on the bond strength of the influence is not obvious, while the age of more than 28d specimens due to the greater shrinkage of the concrete, the bond strength will be with the diameter and thickness ratio increases and decreases. According to the previous researchers, (Aly et al., 2010), the influence of loading regime, concrete strength and age as variation parameters on the bond strength of steel tube concrete was investigated. The test results show that the bond strength decreases with the use of high-strength concrete components compared to ordinary concrete components. The age period was within 100 days and there was a slight decrease in the bond strength with increase in time. Wu Jian-bin et al. (2007) conducted nine square specimens which were designed to be tested with the variation parameters of width-to-thickness ratio (w/t) and length-to-thinness ratio (l/t) of the members, and the test results revealed that the w/t was negatively correlated with the bond strength, while the increase of the l/t basically did not change the bond strength. Whereas KANG Xi-liang (2008) has worked on nine specimens which were designed for testing with the change parameters of l/t, diameter to thickness ratio (d/t), and steel content, to study the size of bond strength and slip on the interface between the steel tube interior and concrete and its change rule. The test results show that in a certain range, the bond strength increases with the increase of the l/t (12.58~17.61), and then decreases with the increase of the l/t (17.61~22.64); when the d/t varies from 28.91 to 39.75, the bond strength decreases with the increase of the d/t of the member; the bond strength increases with the increase of the steel content rate.

On the other hands, Liu Yong-Jian et al. (2010) studied regarding the longitudinal shear bond properties of 20 square and circle CFST specimens by using length-diameter ratio (l/d) and d/t as parameters. The experimental results show that the interfacial bond - slip curves of square and circle CFST specimens have similar variation rules, and the interfacial shear bond strength of circle CFST specimens is greater than that of square CFST specimens. The bond strength increased slightly with the increase of concrete age, increased with the increase of l/d, and decreased with the increase of d/t. However, the effect of concrete strength on bond strength was not significant. Xu Kaicheng et al. (2011) studied seven specimens which were designed to carry out the test by applying different proportions of butter on the inner surface as a variation parameter to obtain the magnitude and composition of the adhesion between the steel tube and the concrete. The results show that the interfacial bonding force of CFST is composed of chemical bonding force, mechanical biting force and friction force. The chemical bonding force is small and disappears immediately when there is relative slip between steel tube and concrete. Mechanical bite force accounts for 20%~30% of interface bonding force. The friction force is the main part of the interface bonding force. The average bonding strength between the inner wall of the untreated steel tube and the concrete interface is 1.2-1.3 MPa. With the increase of the ratio of the inner wall of the steel tube to the concrete, the interface bonding strength gradually decreases. Only friction exists on the interface of CFST members with all interface disadhesion, and the average bonding strength is 0.3 ~ 0.4MPa. Xu Kaicheng et al. (2012) also conducted a research consisted of nine square specimens that were designed to carry out tests

with the parameters of w/t and water-cement ratio (W/C), and the results showed that the w/t and W/C were negatively correlated with the interfacial bonding strength; the ultimate bonding strength increased significantly with the increase of the wall thickness of the steel tube; and the stress and strain at the loaded end of the steel tube were always the largest and grew rapidly with the increasing of the external loads.

BONDING PROPERTIES OF NEW CONCRETE MATERIAL CFST

Ke Xiaojun et al. (2015) have conducted research on the four high-strength CFST specimens were designed with concrete strength and CFST bonding length as research parameters. The results show that the bond strength between steel tube and concrete increases with the increase of concrete strength and bond length. Whereas another researcher, Wu Bin et al., (2020) have conducted another concrete bond-slip properties of circular and square red mud CFST with four varying parameters: red mud substitution rate, concrete strength, l/d ratio (embedment length) or w/t ratio, and d/t ratio. The results show that the bond limit load increases with the increase of concrete strength and steel tube l/d ratio, decreases with the increase of w/t ratio (d/t ratio), but increases first and then decreases with the increase of red mud substitution rate. Xu Jinjun et al. (2013) have been using the recycled coarse aggregate replacement rate, concrete strength grade and l/d ratio as the variation parameters for four groups of 15 circular steel tube recycled concrete specimens which were designed for various type of testing. The test results revealed that the development of interfacial bond damage advanced with the increase of recycled coarse aggregate substitution rate; the increase of interfacial embedment length was favorable for its bond-slip energy dissipation. When the l/d ratio was in the range of 1.86-2.93, the peak loads of the specimens with larger l/d ratios were all larger than those with smaller l/d ratios. Chen Zongping et al. (2013) has been investigated a group of twenty-five circular and square steel tube recycled concrete short column specimens which were designed for launching tests with five varying parameters: specimen cross-sectional form (circular and square), recycled coarse aggregate substitution rate, concrete strength grade, l/d ratio, and interface embedment length. The results show that the bond strength decreases with the increase of l/d ratio, and the bond performance of circular specimens is better than that of square specimens. For the square specimens, the bond strength increased slightly with the increase of substitution rate and concrete strength; for the circle specimens, the change of aggregate substitution rate caused a certain fluctuation of the bond strength. Guan et al. (2019) were taking the type of stone (limestone or pebble) used for sand production, the ratio of steel tube d/t, the compressive strength of concrete (C60, C80, C100), and the content of stone dust as the varying parameters, 27 specimens of CFST with mechanism sand were designed to carry out the launching test. The test results reveal that the bond strength of the mechanism sand specimens is higher than that of the natural sand specimens, the limestone mechanism sand specimens are slightly higher than the pebble mechanism sand specimens, and the bond strength decreases with the increase of the d/t ratio of the steel tube; for the mechanism sand specimens, the stone powder content has a small effect on the bond strength, and there is no uniform pattern of the effect of the concrete strength on the bond strength. Meanwhile Sha Meng et al. (2023) used sixteen specimens which were designed with the strength grade, stone powder content and steel tube w/t ratio as changing parameters. The research results reveal that the bonding strength of square steel tube limestone sand specimen is higher than that of square steel tube pebble sand specimen. The average bonding strength of square steel tube limestone sand specimen is 5.2% higher than that of pebble sand specimen, and the minimum increase is 1.2%. The largest increase was 13.7 percent. On the other side, Wang Qiuwei et al. (2022) have used eighteen square steel tube UHPC specimens which were designed with steel tube w/t ratio, height-width ratio and UHPC strength as the variation parameters to carry out the launching test. The test results reveal that the bond strength decreases with the increase of w/t ratio and height-width ratio, and when the w/t ratio is larger, increasing the UHPC strength can obviously improve the bond strength; establish the calculation model of the bond strength of square steel tube UHPC under two

kinds of maintenance conditions, and the theoretical calculations are in line with the experimental data.

Another group of researchers, Lyu and Han (2019) have tested a total of 56 specimens of recycled aggregate CFST. The test was carried out with the parameters of section type (square, round), section size, RAC strength, regenerated coarse aggregate replacement rate, interface treatment (oil injection, polishing) and so on. The test results show that the section type and size are the two main factors affecting the bonding strength of steel tube and recycled concrete. The bonding behavior of recycled CFST specimens is similar to that of the inner wall of steel tube and the surface of CFST, and the replacement rate of recycled coarse aggregate has no significant effect on the bonding strength of specimens. An empirical formula for calculating the bond strength between core concrete and steel tube is presented. Another group of researchers, Lu, Liu, Li, & Tang (2018) conducted thirty-six FSSCFST specimens which were designed with concrete age (28 days and 2.5 years), steel tube thickness (2.5mm, 3.5mm, 4.25mm), and steel fiber volume percentage (0% and 1.2%) as parameters. The results show that the bond strength and slip amount of specimens increase with the increase of concrete age. The addition of steel fiber can improve the adhesion of the specimen at the early stage, but its effect gradually disappears with the increase of age. The bond strength in the same direction decreases with the increase of loading period, but the steel fiber can delay the bond strength reduction. Based on Lu, Liu, Li, & Li (2018), a total of 90 specimens which were designed with the parameters of concrete type, steel tube thickness, concrete strength and steel fiber volume percentage were tested. The results show that the bond strength of FSSCFST specimens is generally higher than that of self-compacting CFST specimens, and its value is between 0.50 and 2.51 MPa. For SCCFST and FSSCFST specimens, the bond strength increases with the increase of concrete strength or steel tube thickness, and decreases first and then increases with the increase of steel fiber volume content. The bond strength of CFST specimens can be significantly improved by self-stress, with an average increase of 42.7%. whereas Tao et al. (2016) have conducted testing with a total of twenty-four specimens which were designed to carry out the experimental study with varying parameters of section size, steel tube material, concrete type, concrete age, and interface type. The results show that the bond strength of stainless-steel tube members is lower than that of carbon steel tube members and decreases significantly with the increase of section size and concrete age. Among the different interface types, the welded inner ring on the inner surface of the steel tube is the most effective method to improve the bond strength, followed by welded shear studs. The use of expanded concrete was also effective in improving the bond strength.

BONDING PROPERTIES OF CONCRETE-FILLED STEEL TUBE FOR NEW PIPES

With stainless steel instead of carbon steel, the binding strength is reduced by 32% to 69% (Tao et al., 2016). This is mainly due to the low surface roughness of stainless steel. On the other hands, Cao et al. (2023) have designed twelve UHPC-FHSST specimens with concrete strength, l/d ratio and d/t ratio as changing parameters. The results show that the bond strength of HSST and UHPC decreases with the increase of d/t ratio, l/d ratio and concrete strength. Other researchers, Wang Zhengzhen et al. (2019) have designed four groups of 19 specimens for testing. The bonding properties of FRP tubular concrete piles and CFST piles were compared according to the bonding methods (direct bonding, internal screw threads, internal shear parts and composite joint specimens), concrete types (ordinary concrete and expanded concrete), slenderness ratio of specimens and outer tube wall thickness. The results show that the bond strength of CFST specimens is obviously greater than that of FRP tube specimens under the same test conditions. Using expansive concrete, increasing the l/d ratio of the specimen and increasing the wall thickness of the outer tube can improve the bonding strength of the specimen, but the effect of using expansive concrete is the most obvious, which can increase the bonding strength by nearly 10 times. Different bonding methods can improve the bonding strength of FRP tube concrete specimens. Recent research conducted by Luo Peiyun et al. (2021)

used the orthogonal test method to design 9 specimens of welded CFST with d/t ratio, concrete strength and interfacial bonding length as parameters. The test results show that the factors affecting the bond strength and ultimate bond strength are, in order of priority, the d/t ratio of the steel tube, the concrete strength, the interfacial bond length, and the bond strength and ultimate bond strength decrease significantly with the increase of the d/t ratio of the steel tube and increase with the increase of the concrete strength.

Fourteen specimens were designed with the ratio of section W/t, concrete strength, type of ribbed reinforcement and grade of stainless steel as varying parameters by Dai et al. (2022). The results show that the ratio of section W/t, the strength of concrete and the grade of stainless steel have significant effects on the ultimate bonding stress of the specimens. In addition, Han et al. (2022) were regenerated the stainless steel tube where the concrete specimens bond slip test is carried out, and its results show that with CFST specimens, the bond strength of stainless steel tube regenerated concrete specimens is lower, which is mainly due to the smooth surface of stainless steel tube, and the larger shrinkage and deformation of core concrete. At the same time, the formula for calculating the bond strength of stainless steel tube regenerated concrete specimens is proposed, and a finite element model is established for comparison and verification. Previous researchers, Y. Chen et al., (2017) were used height-to-diameter ratio, D/t ratio and concrete strength as changing parameters, 32 stainless steel hollow steel tube specimens were designed to carry out repeated push-out tests. The results reveal that the shear failure load decreases gradually with the increase of repeated push-out tests. The ratio of height to diameter, ratio to D/t and strength of concrete have no significant effect on shear resistance. The comparison also shows that the existing rules on bond strength of carbon CFST design code are not applicable to stainless steel CFST specimens. Song et al., (2023) were designed fifteen specimens with the target temperature, high temperature duration, elliptic section length and section type (ellipse, circle and square) as the variable parameters. The results show that high temperature and its duration have a significant effect on the post-fire bond strength of the specimens, and the post-fire bond strength of the specimens increases with its increase. The bond strength of elliptical specimens is generally lower than that of circle and square specimens when the same concrete strength grade and interface contact area are equal.

BONDING PROPERTIES OF CONCRETE-FILLED STEEL TUBE UNDER SPECIAL CONDITIONS

Z. Chen et al. (2022) were designed a total of 40 samples (20 round and 20 square columns) with different high temperature, mass replacement rate of regenerated coarse aggregate and cross-section shape as research parameters. The results show that high temperature and mass replacement rate of regenerated coarse aggregate have different degrees of influence on bonding behavior and interface damage resistance. By analyzing the bond property and interface damage resistance, it is found that the round specimen is generally stronger than the square specimen. Previous researchers, Chen Zongping et al., 2017) were using the concrete strength, temperature and anchoring length as parameters, 17 samples of high-strength square CFST were designed to carry out high-temperature tests. The results show that the bond strength is inversely proportional to the anchoring length, and increases first and then decreases with the increase of constant temperature. With the increase of constant temperature, the development of adhesive damage of the specimen is late and slow. The energy dissipation capacity of interfacial bonding increases with the increase of concrete strength and decreases with the increase of ergodic temperature. Previous researchers (Chen Zongping et al., 2020; Chen Zongping & Zhou Ji, 2020) were designed a total of 44 steel tubular high-strength concrete specimens (22 circle and 22 square) with the varying parameters of concrete strength, maximum temperature, anchoring length, constant temperature duration and cooling method. The results show that with the increase of the maximum temperature, the interface bonding properties of the two types of steel tube specimens are significantly different after cooling by water spray at high temperature,

and the performance indexes of the circular steel tube specimens are better than that of the square steel tube specimens. The bond strength of the square specimen is more affected by the constant temperature time and increases with the constant temperature time. With the increase of anchoring length, the interface bond strength decreases, which has greater influence on the shear bond stiffness and energy dissipation capacity of the circle specimen. The shear bond stiffness of the specimens with two types of cross section is opposite. Compared with the naturally cooled specimens, the water-cooled specimens have lower bond strength and shear bond stiffness, and better energy dissipation capacity. Increasing the strength of concrete can improve the bond strength. Based on fire exposure time, section type, section size, interface L/D (L/W) ratio, concrete type, fly ash type and concrete curing conditions, 64 specimens were tested (Tao et al., 2011). The results show that fire has a significant effect on bonding strength. After 90 minutes of fire exposure, it is usually observed that the bond strength of the specimens decreases. However, when the exposure time was extended to 180 minutes, the bond strength recovered somewhat. Other researchers, Parsa-Sharif et al. (2023) used the exposure temperature, L/D ratio, D/t ratio, grade of cementing material and type of concrete (pumice lightweight concrete and ordinary concrete) as the research variables to carry out an experimental study on pumice lightweight CFST members. The results show that at 200℃, 400℃ and 600℃, the bonding capacity of light CFST specimens remains relatively unchanged (negligible increase or decrease), and decreases by 84% and 94%, respectively. The bond strength increases with the increase of L/D ratio and decreases with the increase of D/t ratio. In most high temperature environments, high water-cement ratio test parts have greater bonding strength; At a high temperature of 600℃, the bonding capacity of ordinary concrete specimens is about 8 times that of light concrete specimens. Chen Jun et al. (2018) highlighted that the main parameters, such as constant temperature, L/D ratio and D/t ratio, were used to test specimens at constant high temperature. The results show that the average bond strength is significantly affected by constant temperature in the study range of 20℃~900℃. The average bond strength decreases first, then increases and then decreases with the increase of constant temperature, and the decrease range is up to 90%. The average bonding strength decreases with the increase of L/D ratio, and the decrease range is up to 50%. The D/t ratio has little effect on the average bonding strength, and the reduction range is less than 10%. Bahrami & Nematzadeh (2021) presented that the bonding behavior of lightweight CFST specimens containing rock wool waste under high temperature load was studied. It was found that the bonding strength decreased significantly under high temperature environment, but the addition of rock wool could alleviate this trend. Yan et al. (2019) carried out tests with different low-temperature temperatures, concrete D/t ratio, concrete strength grades, L/D ratio, and cross-section types as the varying parameters, and the results showed that the ultimate bond strength decreases with increasing D/t ratio at low temperatures, which is higher in circular than square members, and the value is greater for low-strength concrete; whereas, the effect of L/D ratio on it is small.

BONDING PROPERTIES OF CONCRETE-FILLED STEEL TUBE WITH DIFFERENT INTERFACE STRUCTURES

(Xue & Cai, 1996b) The surface roughness of the steel tube has a significant effect on the interface bond strength, and it is proportional to the roughness. (Dong et al., 2020a)16 large square specimens were designed with steel tube construction measures and concrete types as parameters. The results show that the stud and round bar have a higher cost performance in improving the bonding strength, and the combination of stud and round bar has a better effect. The combination of circular reinforcement and vertical reinforcement significantly improves the bond strength and energy dissipation capacity. The recycled concrete specimens have better bonding properties than ordinary CFST. (Dong et al., 2020 b) Eighteen large-diameter specimens with different structures and concrete types were designed for testing. The results show that the interface of tubes with special structures can improve the bonding properties, and the concrete strength is proportional to the bonding strength.

(Wang et al., 2022) Eighteen specimens were designed with the varying parameters of surface roughness, interface length, concrete age, contact pressure, interface long-term load and modified load. The results show that the bond strength is proportional to the surface roughness of the steel tube, and decreases with the increase of concrete age and interface long-term load. The interfacial length has little effect on the final bonding strength, but it is not conducive to the uniform distribution of bonding stress along the interfacial length. (Chen Lihua et al., 2015) Based on the concrete strength and the height of the pattern bump, 9 samples with internal pattern were designed and tested. The results show that the ultimate bond strength can be significantly improved by the introduction of the pattern steel tube, and the strength is proportional to the height of the pattern bump and the strength of the concrete. And the regression formula of characteristic bond strength can fit the experimental results well. (Dai et al., 2022)14 square stainless-steel specimens were designed with the ratio of cross-section width to thickness, concrete strength, type of ribbed reinforcement and grade of stainless steel. The results show that the addition of ribbed reinforcement can significantly improve the bonding properties.

MAIN FACTORS AFFECTING THE BONDING PERFORMANCE OF CONCRETE-FILLED STEEL TUBE

Through the comprehensive analysis of domestic and foreign research results on the bonding properties of CFST, it can be seen that the research results have a large dispersion, and a mature theory has not been formed. Concrete type, concrete strength and shrinkage properties, steel tube section shape and section size (diameter, diameter to thickness ratio, slenderness ratio), steel tube inner surface structural measures are the main factors affecting the interface bonding properties.

STRENGTH GRADE OF CONCRETE

Previous researchers (Do Hong Ngying et al., 2021; Ke Xiaojun et al., 2015; Lu, Liu, Li, & Li, 2018; LUO Peiyun et al., 2021; Xu Kaicheng et al., 2012; Xue & Cai, 1996b; Yuan Wei-bin & Jin Wei-liang, 2005) show that increasing the strength of concrete can reduce the ultimate bond stress of concrete, but aggravate the shrinkage of concrete. On the other notes, several group of researchers (Y. Chen et al., 2017; Liu Yong-jian et al., 2010; Virdi & Dowling, 1980) show that the bond strength is not obviously affected by the concrete strength. After high temperature, lightweight concrete specimens with smaller cement grades show greater bonding ability (Parsa-Sharif et al., 2023). Whereas another researchers, Yan et al. (2019) concludes that at low temperatures, smaller concrete strength grades show greater bond capacity. As for the influence of concrete strength, domestic and foreign scholars have not reached a unanimous conclusion. The reason may be that the mechanical bite force between high-strength concrete and steel tube is stronger than that between low-strength concrete, but high-strength concrete has large shrinkage, which will reduce the tightness between it and steel tube, resulting in reduced friction. Perhaps there are other uncertain factors, and the influence of concrete strength still needs a lot of in-depth research by domestic and foreign scholars.

WIDTH TO THICKNESS RATIO (DIAMETER TO THICKNESS RATIO)

(Kang Xi-liang, 2008) The bond strength is related to the D/t. When the D/t is 28.91~39.75, the bond strength is negatively related to the D/t. (Cao et al., 2023; Chen Jun et al., 2018; Han et al., 2022; LIU Yong-jian et al., 2010; LUO Peiyun et al., 2021; Parsa-Sharif et al., 2023; WU Jian-bin et al., 2007; XU Kaicheng et al., 2015; Yan et al., 2019) The existing research shows that W/t (D/t) radio is one of the main factors affecting the bonding stress of CFST.

Scholars have basically reached a consensus that the W/t (D/t) radio is negatively correlated with bond strength. This is mainly because the smaller the W/t (D/t) radio, the stronger the constraining effect of the steel tube on the concrete, the greater the normal force on the contact interface, and the greater the bonding strength. However, this value is not the smaller the better, when below a certain limit value, the bond strength should not change significantly. Theoretically, there should be an optimal value interval, in which the bond strength is negatively correlated with the ratio of width and thickness, and the change is regular. However, how to determine the optimal value interval and which factors are related still need to carry out a lot of experimental research or simulation analysis.

SLENDERNESS RATIO / LENGTH-DIAMETER RATIO

Kang Xi-liang (2008) emphasized that the bond strength is positively correlated with the slenderness ratio (12.58~17.61) within a certain range, and negatively correlated with the slenderness ratio (17.61~22.64) beyond this range. This is mainly because the bond strength is mainly provided by friction, when the slenderness ratio exceeds a certain critical value, the impact of the slenderness ratio on the friction between the steel tube and concrete becomes less obvious. In addition, Xu Jinjun et al. (2013) highlighted that when the ratio of length to diameter of recycled CFST specimens is in the range of 1.86~2.93, the peak load of the specimens with large length-diameter ratio is greater than that of the specimens with small length-diameter ratio. Chen Zongping et al. (2013) stated that the bond strength of recycled CFST specimens is negatively correlated with the length-diameter ratio. This statement is in line with the other researchers, Cao et al. (2023) where the bond strength of high strength steel tube (HSST) and ultra-high performance concrete (UHPC) is negatively related to the length-diameter ratio. Chen Jun et al. (2018) also stated that under constant high temperature conditions, the average bond strength is negatively correlated with the length-diameter ratio, and the decrease range is up to 50%. Whereas other researchers, Wu Jian-bin et al. (2007) stated that the change of bond strength was not significant with the increase of slenderness ratio. Yan et al. (2019) also highlighted that at low temperature, the ultimate bond strength is less affected by the change of L/D value. According to the research of domestic and foreign scholars, the influence of slenderness ratio on bond strength has not yet reached a unified conclusion, and further experimental and theoretical research is still needed.

CONCRETE AGE

Previous researchers, (Aly et al., 2010; Wang et al., 2022) have shown that a negative correlation between concrete age and bond strength. Tao et al. (2016) Age has a significant effect on bond strength, and there is a negative correlation between the two. However, for full-size specimens with a normal concrete age of more than three years, the value drops to negligible. (Lu, Liu, Li, & Tang, 2018) Age has a significant effect on the bonding properties of FSSCFST specimens. With the increase of age, the bond strength and the corresponding peak slip are increased, and the bond strength is increased by 37.5% on average.

As far as the existing research is concerned, the effect of age on bond strength has not yet been recognized. In the author's opinion, the bond strength may be related to the type of concrete, for ordinary concrete, the bond strength is negatively correlated with the age, which is due to the shrinkage of the concrete caused by the two materials are not bonded tightly enough to cause a decrease in friction. For special functional concrete, its age and bond strength is positively correlated, such as the use of expansion concrete, with the increase in age, the bond strength also increased.

INTERFACE STRUCTURE OF DIFFERENT STEEL TUBES

A researcher, Shakir-Khalil H (1993) has squeeze and build-up effects can be created by the increased installation of shear connectors or welded bearings, which have a positive effect on improving bond strength. Whereas another researchers, Wang et al. (2022 and Xue & Cai (1996b) had mentioned that the surface roughness of the steel tube had a significant effect on the bond strength, which was highly positively correlated. Whereas Chen Lihua et al. (2015) stated that the use of patterned steel plates instead of ordinary steel pipes significantly increases the ultimate bond strength; the ultimate bond strength is positively correlated with the height of the patterned projection and the concrete strength. Other researchers, Tao et al. (2016) highlighted that the different interface types for steel tubes, all had a positive effect on increasing bond strength. The order of prioritization for comparing the final effects was welded inner rings on the inner surface of the steel tube, welded shear studs, and application of expanded concrete. This is in line with the research on different structural measures for square and circular steel tube concrete setups were carried out respectively, and the results showed that the structural measures for the steel tube interface all have positive effects on improving bond strength and energy consumption capacity (Dong et al., 2020a, 2020b). To summarize the existing studies, the steel tube interfacial configuration is advantageous for improving the bond strength. The influence of the inner wall roughness and shear bond on the interface bonding performance is very obvious. The rougher the inner wall is or the shear bond is set, the greater the adhesive strength and energy dissipation capacity will be.

SECTION TYPE AND SIZE

Morishita Y & Tomii M (1979) were first found that the bond strength varies with the cross-section shape of the member, specifically from square→octagonal→circular and increases gradually. There is a study conducted by Shakir-Khalil H (1993) of square, polygonal, and circular steel tube specimens concluded that the adhesion of circular steel tubes was greater than that of polygonal and greater than that of square. Chen Zongping et al. (2013) had compared the interface bonding and sliding performance test of recycled CFST, the bonding performance of circle specimens was better than that of square specimens. On the other side, Tao et al. (2016) highlighted that for specimens of the same cross-sectional size, circular columns have higher bond strength than square columns. The bond strength between carbon steel tube members and stainless steel tube members decreases significantly with the increase of section size. Post-fire square, circular, and elliptical steel tube concrete bond-slip tests were conducted, and it was found that the bond strength of elliptical cross-section specimens was generally lower than that of circular and square specimens for specimens with different cross-section types but the same concrete interfacial contact area (Song et al., 2023).
It is found through the test that the specimens with circular section can obtain greater bond strength than those with square section, which is also the conclusion that the analysis of factors affecting the bond strength of CFST has reached a unified understanding. This is mainly because the stiffness of the four corners of the square steel tube is much greater than that of the four sides. Under pressure, only the four corners can effectively constrain the concrete, while the four sides will flex and expand under the pressure. Only when the concrete is close to the circle will it exert the greatest restraint effect. Therefore, concrete filled steel tube with circular section has the strongest bonding property.

CONCLUSIONS

In this paper, the research results related to the bonding properties of CFST specimens are reviewed. The main conclusions are summarized as follows:

(1) W/t (D/t) radio is one of the main factors affecting the bond strength. Generally, the w W/t (D/t) radio is negatively correlated with bond strength.
(2) The interfacial structure of steel tube is favorable to improve the bonding strength. Interfacial bonding performance is affected by the roughness of the inner wall of the steel tube and shear bonding is very obvious, the rougher the inner wall or set up with shear bonding, the greater the bonding strength, the greater the energy dissipation capacity.
(3) Specimens with circular section can obtain greater bond strength than those with square section. There is still no uniform conclusion on the influence of concrete strength, concrete age and the slenderness ratio of specimens on bond strength, and further research is still needed.

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FACTORS INFLUENCING CONSUMERS' GREEN PURCHASING INTENTION: A SYSTEMATIC REVIEW

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ABSTRACT

Green procurement is pivotal in achieving the Sustainable Development Goals (SDGs) and has garnered increasing attention from consumers. This study aims to contribute to the understanding of factors influencing green purchasing intention through a systematic literature review (SLR) conducted via PRISMA methodology. Analyzing 39 papers from the Scopus database spanning 2017 to 2022, we structured our investigation around variables such as country of origin, publisher, journal of publication, influencing factors, and theoretical frameworks employed. Our findings underscore the complexity of green purchasing intention, shedding light on multifaceted influences ranging from individual beliefs to societal norms. Importantly, we identify avenues for future research, including the exploration of multilingual database resources to ensure a comprehensive understanding of the determinants of green purchasing intention. This study fills a gap in the literature by providing insights into the nuanced interplay of factors shaping consumer behavior toward sustainable procurement. Moreover, it offers practical implications for policymakers and businesses seeking to promote green purchasing initiatives, emphasizing the need for targeted interventions informed by a thorough understanding of consumer motivations

Keywords:
Purchasing intention, green purchasing, influence factor, environment

INTRODUCTION

The context in which individual consumer behavior unfolds is profoundly shaped by broader societal and economic forces. The relentless march of economic development and industrialization has bestowed upon individuals greater material purchasing power, ushering in an era of unprecedented consumption (Lin et al., 2017). However, this surge in affluence has come at a cost, with studies linking overproduction and over-purchasing to a surge in global environmental and ecological challenges (Fan et al., 2015).

As individuals exercise their newfound purchasing power, the ramifications for the environment cannot be overstated. Non-green purchasing behaviors, characterized by little regard for ecological consequences, contribute significantly to environmental degradation (Lacy & Hayward, 2011). In response, the concept of green purchasing has emerged, reflecting a growing awareness among consumers of their environmental footprint and a desire to mitigate it (Laukov, 2013).

Yet, transitioning from entrenched non-green purchasing habits to more sustainable alternatives poses formidable challenges. Scholars have underscored the complexity of this transition, citing societal norms and entrenched consumption patterns as formidable barriers (Burgess, 2003). Moreover, the imperative of sustainable development adds another layer of complexity, emphasizing the responsibility of affluent societies to address global inequalities and environmental degradation (Ahmed Mohamed and Ibrahim, 2021).

Crucially, individual behavior is not an isolated phenomenon but is influenced by a myriad of factors, including subjective norms and environmental attitudes (Cheung & To, 2017). Predicting

consumer purchase intentions, therefore, proves challenging, particularly given the array of competing influences (Zhuang et al.2021). Against the backdrop of escalating environmental challenges, the imperative for green purchasing has never been clearer, yet studies suggest a gap between intention and action among today's consumers (Tariq et al.2019; Haws et al.2014).

In the context of escalating environmental challenges and the imperative for sustainable consumption, understanding the determinants of green purchasing behavior assumes paramount importance. This research endeavors to illuminate the multifaceted factors shaping consumer choices, with the overarching goal of informing strategies to foster more sustainable consumption patterns and mitigate environmental degradation.

To address this objective, the study aims to systematically review and analyze existing research on the various factors influencing green purchase intention (GPI). This preliminary investigation is guided by several key questions:

Question 1: What factors exert influence on GPI?

Question 2: Which of the factors influencing GPI have received greater attention in existing literature?

Question 3: What avenues exist for future enhancement and refinement of GPI research?

OBJECTIVE OF THE STUDY

Objective 1: To comprehensively explore and analyze the diverse factors that influence GPI.
Objective 2: To identify and assess the prevalence of factors frequently studied in the context of GPI.
Objective 3: To delineate potential pathways for advancing and refining research on GPI.

Utilizing PRISMA methodology, this study delves into a vast array of literature to better understand the factors driving consumers' intentions to purchase green products. Through rigorous analysis and synthesis of existing research, this study aims to provide valuable insights that can inform policy-making, business strategies, and future research directions in the realm of sustainable consumption.

Compared with the previous literature, this article mainly makes the following contributions. First, we used Scopus as the main database to conduct a detailed review and systematic analysis of the papers from January 2017 to May 2022 (a five-year review is more common as can be seen in studies such as Zhang & Dong, 2020) and updated the previous research results. Second, the research scope is clear and definite, that is, the influencing factors of consumers' green purchasing intentions. The influencing factors with higher frequency were summarized and analyzed, and further divided into internal factors and external factors. Third, the present study statistically analyzed the most frequently used theoretical frameworks applied in green purchasing research, and pointed out the deficiencies of these theories, which can contribute to future research.

The structure of this study is as follows. The first section is literature review. Section 2 introduces the research method, including the following parts: research design, research questions, research procedures, research literature collection requirements, and literature screening process. Section 3 displays the research results, characteristics of paper publications on green purchasing (number of publications, publication year, research country, publications, and database information), influencing factors (internal factors and external factors), and theoretical research foundation. The discussion of this paper is in Section 4. Section 5 contains conclusions, limitations, and recommendations for future research.

LITERATURE REVIEW

Currently, the exploration of the influencing factors of green purchasing behavior is in its nascent stage, with limited relevant research findings available from related fields. Despite its crucial importance, the understanding of green consumer behavior, which falls within the realm of environmental behavior, remains largely confined to the point of purchase.

Early scholars have attempted to define consumers' inclination towards purchasing environmentally friendly products, commonly termed as green purchase intention. However, existing literature lacks comprehensive coverage and suffers from several notable shortcomings. For instance, while some scholars have focused on consumers' positive attitudes towards green products or services, others have emphasized the proactive inclination to purchase such items. This lack of consensus among scholars leads to ambiguity and hinders the development of a unified framework for understanding green purchase intention (Schneider et al., 2001; Huang & Wang, 2020). Moreover, despite attempts to conceptualize green purchase intention as a latent consumer mindset motivating actual purchases, there is a dearth of empirical evidence supporting this assertion (Gao Jian, 2021).

Additionally, the existing body of research on green purchase intention primarily concentrates on consumer psychology and green marketing investigation. However, many studies in these domains suffer from methodological limitations and inconsistencies in results. For instance, while some studies utilize established behavioral theories to explore the cognitive decision-making process behind green purchasing behavior, others lack theoretical grounding and rely on ad-hoc methodologies (Dodds et al., 1991; Sheng et al., 2019). Furthermore, within the realm of green marketing, the focus on identifying obstacles posed by price premiums associated with green products overlooks other critical factors influencing consumers' purchasing decisions, such as product availability and perceived convenience (Olsen et al., 2014; Groening & Zhu, 2018).

In summary, existing literature on green purchase intention exhibits significant deficiencies, including a lack of consensus among scholars, methodological shortcomings, and inconsistencies in research findings. Addressing these deficiencies is essential for advancing our understanding of green consumer behavior and developing effective strategies to promote sustainable consumption practices (Javed et al.,2019; Kumar et al.,2019).

METHODOLOGY

Research Design

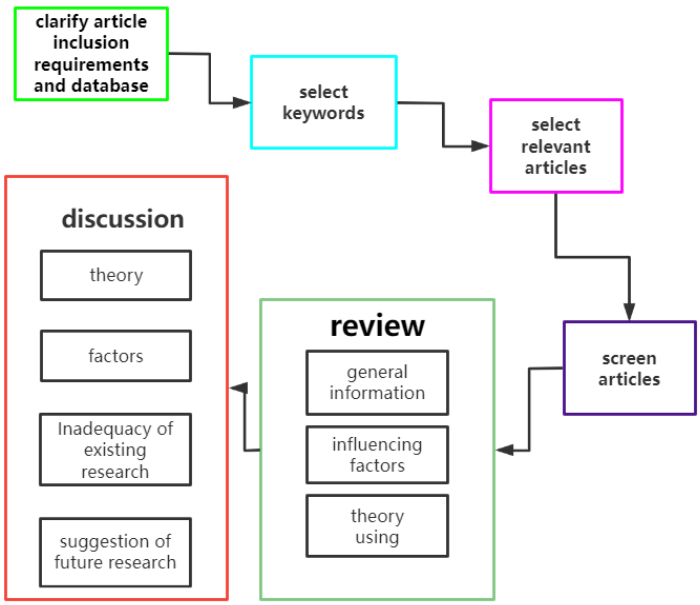
An essential goal of a Systematic Literature Review (SLR) is to identify the key research gaps based on the structure, theories, and methods used in different circumstances as well as the research background (Al Jahwari et al., 2021). SLR allows the implementation of three stages namely planning, conducting research and mapping. It enables researchers to identify specific research gaps and context of the study (Sulaiman et al. 2022). In this study, the SLR method was used to collect, screen, and analyze the relevant literature. The SLR is a commonly used research method to accurately summarize the main points of the literature (Liberati, 2009).

This research conducted an SLR according to the following steps: (1) figuring out accurate and suitable keywords, (2) identifying related papers in the database, and (3) reading and refining the core of related papers. These papers are only selected from the Scopus database. The six-step structure as depicted in Figure 1 was used for further elaboration

Research Procedure

1. Clarifying article inclusion requirements and database
2. Choosing keywords related to the research topic, with these keywords divided into two large groups:
   The first group: social media use, price sensitivity, government policy, cultural environment, media promotion, media persuasion, and environmental concern
   The second group: young consumers, purchasing behavior, purchasing intention, green purchasing, and planning behavior theory
3. Applying a combination of keywords from the above categories to collect relevant papers
4. Screening papers from different perspectives
5. Reviewing effective general information of the papers, identifying factors that influence green purchasing motivation and the theory to be used
6. Summarizing the research results, analyzing the influencing factors, putting forward the deficiencies of existing research, and making suggestions for future research.

Figure 1: Research steps (Own source)



Requirements for the Collection of Research Papers

The literature for this study was sourced solely from Scopus (Chadegani et al., 2017; Mazur, 2021), one of the most valuable electronic academic databases in the scientific system. Papers selected were all published in English-language academic journals from January 2017 to December 2022. It has been suggested that if the most recent reference is more than 5 years old or so, it may indicate that a full and up-to-date review of the literature has not been conducted (Santini, 2018). The selection requirements for academic journals are as follows: non-theoretical model research; not a conference report or a doctoral dissertation or a seminar paper; a completed paper; not a chapter of a book; not a conference publication (including conference minutes, posters, and abstracts). To address the research questions, the keywords "green purchasing intention", "green purchase", "purchase intention", and

"influencing factors" were used as keywords in the title and abstract, and a comprehensive literature review was obtained.

Document Screening Process

The screening process is based on the PRISMA process proposed by Liberati et al. (2009). It consists of four main steps: identification, screening, eligibility, and inclusion.

Firstly, 1,409 documents were screened in the Scopus search through a reasonable combination of keywords. Second, according to the thematic classification of the literature, literature with little relevance to green purchasing and purchasing intention (734 articles) was excluded, leaving 675 articles. Then, 38 duplicates were excluded, resulting in 637 valid documents. After that, 453 papers outside the scope of the study were excluded, leaving 184 papers. Of these 184 papers, 145 papers that dealt with non-purchasing behavior or lack of willingness to consume green were identified and removed. In the end, 39 valid papers were produced.

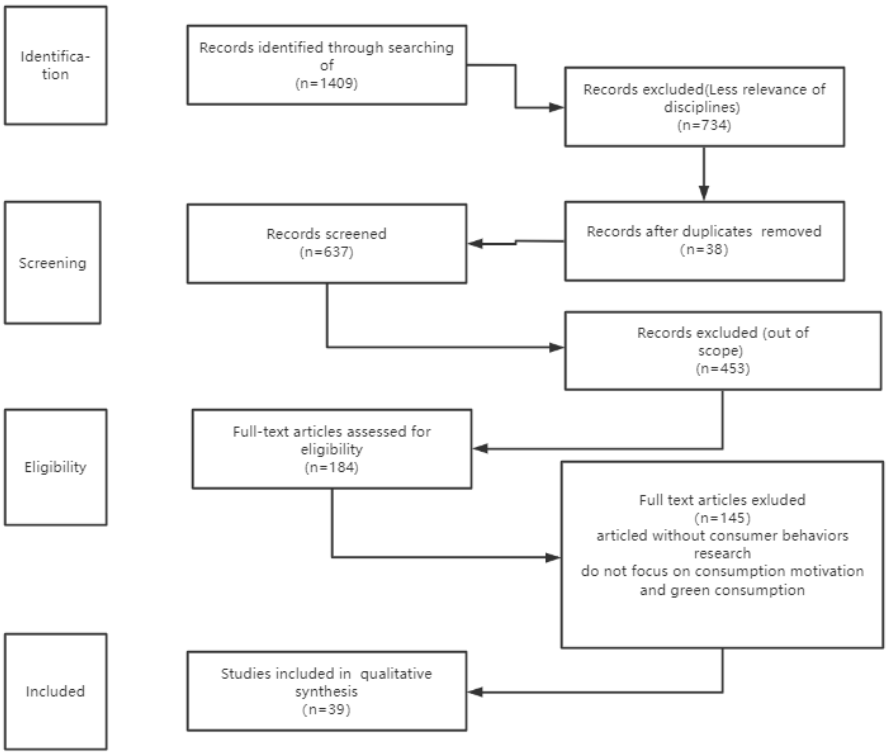


Table 1: PRISMA Flow Chat. n=number of documents

FINDINGS

Characteristics of GPI Papers Publication

A total of 39 papers related to green purchasing published in several Scopus academic journals from 2017 to 2022 was chosen for this SLR. They were distributed in various fields, including energy, real estate, new energy vehicles, religion, psychology, clothing, and media. With so many disciplines covered, it is not an easy task to explore the intention of green buying behavior, as it requires knowledge of a variety of fields.

Publication Year

We examined the papers published between 2017 and 2022 to figure out the publication trend of the papers. As can be seen from Figure 3, the number of papers published on consuming intention and green purchasing increased year by year from 2017 to 2022. Among them, 2021 had the most publications, with a total number of 17.

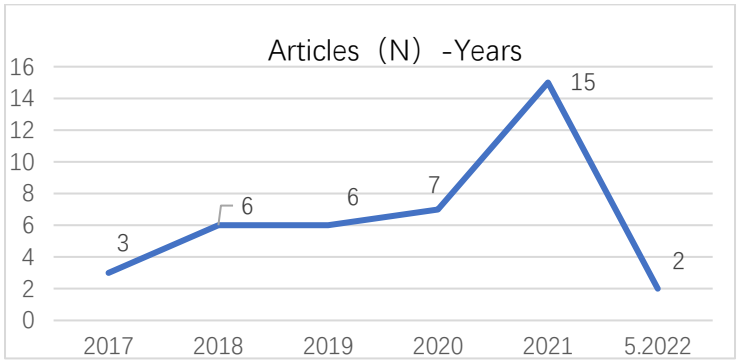


Figure 2: Literature publication trend graph. n=number of documents

Type of Publisher

The contributions of various publishers were summed up. According to the figures, Elsevier ranked first, with the most papers of eight, followed by MDPI with seven papers. Figure 3 shows the specific sources for each paper.

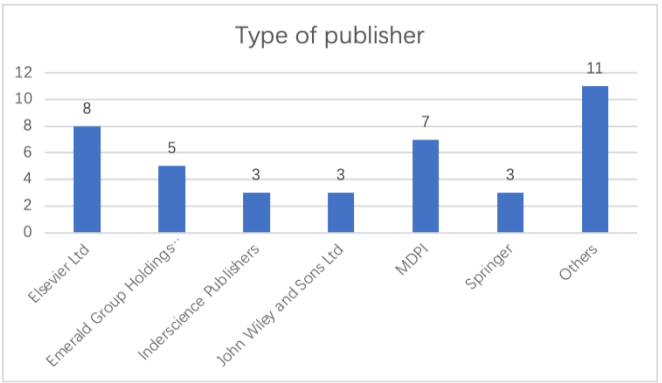


Figure 3: Type of publisher.

Types of Journal Publication

The source journals of the literature were summarized and counted. Journals with a single publication are classified as other journals (n=25). It can be observed that Sustainability is the journal that publishes the most papers (n=6). The topics of this review cover a wide range of academic fields, such as marketing, environment, and business. The types of journal publications are shown in Figure 4.

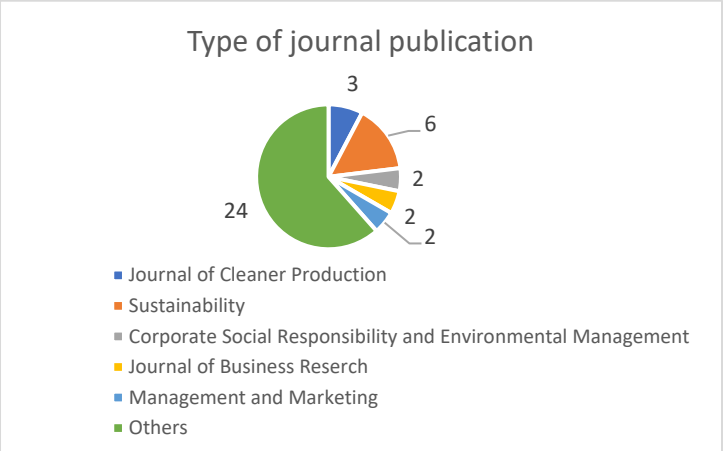


Figure 4: Type of journal publication

Type of Country

This study collected the mailing address of the first author of each paper and figured out the nationalities of the authors. According to the results, it can be seen that China and India are the largest sources of articles, followed by Malaysia.

The countries as the origins of the literature are shown in Figure 5.

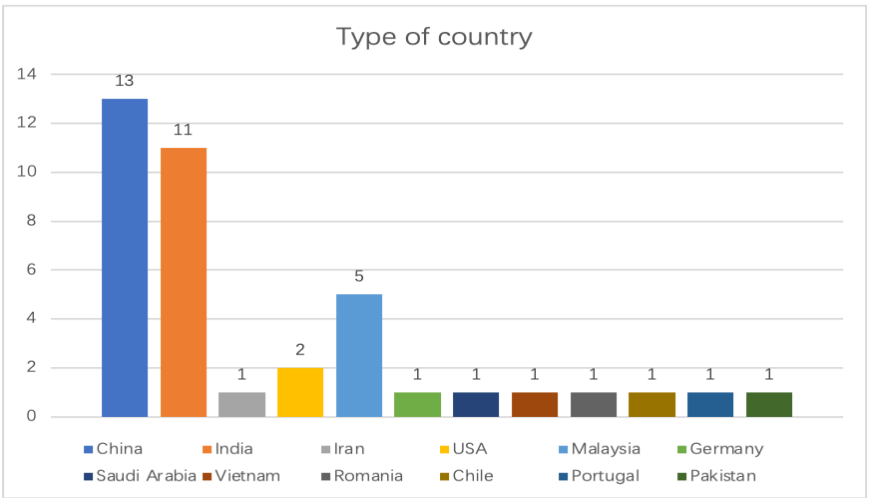


Figure 5: Type of country

Influencing Factors

The influencing factors of consumers purchase intention studied in the literature were summarized. Factors such as price sensitivity, environmental concerns, social media, and government support have been more emphasized in the research on consumers' purchasing behavior in recent years. Among all the influencing factors involved, price sensitivity was studied most frequently, and the influence of non-governmental organizations was emphasized least frequently. The research frequencies of influencing factors are shown in Figure 6.

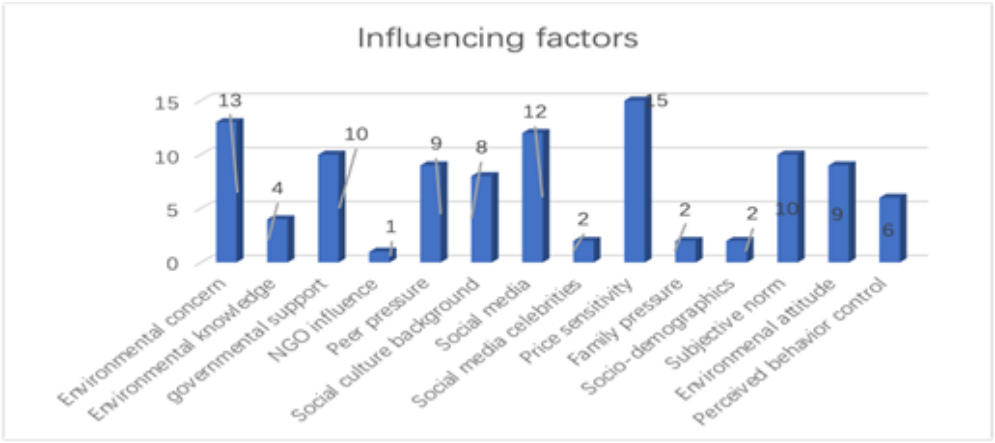


Figure 6: Influencing factors

These influencing factors can be divided into two major categories: the internal factors related to the individuals themselves (psychology, attitude, consciousness, values, morals) and the external factors that exert imparts on the individuals (social norms, social forces, media power).

Internal factors include environmental concerns, environmental knowledge, price sensitivity, environmental attitudes, subjective norms, perceptual behavior control, and social demographics. External factors include government support, peer pressure, social media, social media celebrities, non-governmental organizations, family pressure, and cultural background.

In this study, among the factors influencing green purchasing, internal factors are studied more frequently than external factors. However, it should be noted that even for the same influencing factors, there are different research results. There are studies that concluded that environmental attitudes have a greater impact on consumers' green purchasing intention; there are also studies that put forward the opposite opinion in that environmental attitudes do not present a correlation with consumers' green purchasing intention (Trivedi et al., 2018; Visser, Dlamini. 2021).

According to the SLR summary, there is no uniformity in the definition of environmental concerns. However, environmental concerns are categorized into two types in most studies: environmental concerns about specific environmental issues and general environmental concerns (Yue, et al., 2020). As one of the influencing factors of green purchasing intention, some studies use it as a direct influencing factor, while some studies use it as a mediating factor between other influencing factors and green purchasing intention (Young et al.,2010).

Price sensitivity is also one of the influencing factors that appear more frequently in this SLR, and the studies on price sensitivity for residents of developed countries are lower than those of developing countries. The differences in green behavior of consumers depend on their price sensitivity to the purchasing of green products; it is argued that price sensitivity and the price itself are the key determinants of the consumers' willingness to make green purchases (Marwat & Ahmad, 2020).

Simultaneously price sensitivity is also considered as a mediator between green purchasing intention and other influencing factors (Marwet et al., 2022; Chen &Kian,2021).

This research also found that the influence of social media is one of the important research objects in the field of green purchasing research in recent years. Existing research suggests that advertisers are shifting from traditional media to social media platforms because social media is more cost-effective and easier to reach target audiences than traditional media (Nekmahmud & Fekete, 2022). Most studies suggest that the influence of social media on consumers' green purchases is not direct, but rather indirect through other influences. Some studies suggest that social media can play an important role in changing consumers' attitudes toward green products, and social media advertisements have also been shown to help increase consumers' knowledge about environmentally friendly products (Zhao & Lee, 2019; Sun& Wang, 2020). Social media users are highly interactive with each other, and frequent information exchanges and word-of-mouth transmission can influence users' offline behavioral intentions (Tan,2023).

In the field of green purchasing, this SLR found that subjective norms have a greater impact on consumers' green purchasing intentions. Subjective norms are the group's evaluation of the appropriateness of an individual's behavior, which can exert some social pressure on the individual to perform a certain behavior (Sun & Xing, 2022). Especially in some East Asian countries and regions where collectivist values are dominant such as China and South Korea, the green purchasing intentions of consumers in these countries and regions are easily influenced by the behaviors of the community, family and friends (Lee, 2017). Also, subjective norms are often analyzed together with other influencing factors, for example, social media and mass communication reinforce users' subjective norms. Celebrities' retweeting of green product information on social media can be effective in raising fans' environmental awareness in the form of social demonstration (Chwialkowska, 2019).

Theoretical Foundation

The research on green purchasing intention involves disciplines such as consumer psychology, marketing, social psychology, cultural science, and economics, among others. Some theoretical frameworks are highly applicable to the research of green buying behavior. After collating the literature, most of them applied the planned behavior theory (TPB) (n=12), followed by the stimulus-organic-response theory (SOR) (n=2). At the same time, many documents expand and innovate the original theories, and even use a mixed theory (Sang et al., 2020).

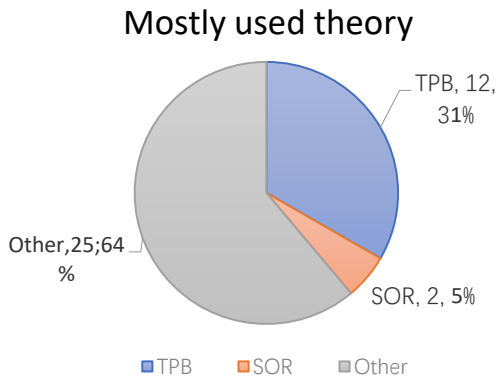


Figure 7: Mostly used theory

DISCUSSION

Whether in developing or developed countries, the research on consumers' green purchase intention has attracted much attention, yielding rich research results (Gonzalez et al., 2015). Some researchers try to identify the impact of individual values, social norms, and other factors on consumers (Naderi & Steenburg, 2018). Some researchers intend to explore consumers' attitudes and environmental concerns (Esmaeilpour & Bahmiary, 2017). In addition, some researchers investigate GPI from consumers' own socio-demographic data and price sensitivity (Kundi & Mughal, 2021; Diamantopoulos et al., 2003). Compared with the papers on internal factors, there are fewer studies investigating the impact of external factors on GPI (Kumar et al., 2019), such as peer pressure, social impact, and government measures (Lee, 2010).

According to the SLR result, scholars in various countries mainly adopt intervention research, field investigation, and quantitative analysis to research factors affecting green purchasing intention. The internal factors mainly include environmental concerns, environmental knowledge, price sensitivity, environmental attitudes, subjective norms, perceptual behavior control, and social demographics. The external factors primarily cover government support, peer pressure, social media, social media celebrities, non-governmental organizations, family pressure, and social-cultural background.

Based on the SLR results, the internal factors influencing individual GPI mainly include environmental attitudes, environmental concerns, environmental knowledge, price sensitivity, and social demographic data. Social demographics, involved in internal factors, have a significant impact on consumers' green purchasing intentions and behaviors, according to the literature. It was found that gender, age, education level, income level, and other factors will influence consumers' attitudes toward green products (Diamantopoulos et al., 2003). Specifically, according to the existing studies, men have more positive attitudes toward sustainable product purchasing than women while younger consumers have more positive attitudes toward purchasing green products compared to older people. In other words, when studying the influence of factors on GPI, it is necessary to distinguish groups and conduct research on group characteristics.

Other internal factors also have a considerable impact on consumers' purchasing intentions, for example, consumers' attitudes towards the environment. Previous research has found that attitudes towards green products will influence consumer purchase intention to a large extent (Göçer & Sevil, 2017). Many studies incorporate subjective norms into important variables in the research on consumers' green purchasing (Javed et al., 2019; Chen & Tung, 2014).

Moreover, the SLR results indicate that external factors that influence people's GPI mainly involve government support, social-cultural background, peer pressure, and social media platforms. Among them, social media is one of the most influential factors of green purchasing. Nowadays, social media has become an essential tool for the dissemination of consumer information, and it has been deeply integrated into consumers' daily lives (Ismail, 2017), especially in green purchasing. Studies have found that social media has a particularly strong influence on young people, and it can exert a significant impact on young consumers' purchasing attitudes and intentions towards green products (Huang, 2016; Zhang et al., 2018; Zhao et al., 2019). Plenty of existing documents have shown that social media platforms affect consumer behavior as well (Cao et al., 2021).

Compared with text information, audio content offers greater advantages. It can have more influence on audiences' behavior with the increase of audio content in the age of social media (Lim et al., 2019). Currently, social media is an important reference platform for young consumers when shopping, such as Twitter, IG, and YouTube, especially for fashionable green products (Pandey et al., 2018). Celebrity recommendations and hot recommendations on social media will undoubtedly affect the behavior of many followers (Tengku & Manaf, 2019).

Since the outbreak of the COVID-19 pandemic in 2020, global sales models have undergone tremendous changes, with online shopping becoming an inseparable part of people's daily life (Sun

et al., 2021). Therefore, with the further extension of people's online time, social networks are of great importance serving as the connection between people in the current digital age (Jin & Ryu, 2019). It has developed to become a critical channel of communication between users; it has also become a platform for individual consumers to interact with online marketers (Ryan et al., 2017).

Simple internal factors cannot completely determine consumers' purchasing intentions. Some consumers, for example, may have a favorable opinion towards new energy vehicles, believing that they are environmentally friendly without using fossil fuels. However, the technical flaws of electric cars, such as a short cruising range, slow charging speed, limited charging stations, and high battery maintenance cost, have discouraged many consumers from purchasing them (Pan et al., 2019). Therefore, studying only the internal factors that influence purchasing willingness is insufficient. Consumers' green purchasing will be influenced by a variety of external factors as well, as evidenced by the difficulty of popularizing BEVs.

Additionally, the SLR found that the Theory of Planned Behavior (TPB) is mostly used by previous research on GPI. Aiming at the defect that rational behavior theory cannot explain behaviors that are not completely controlled by the will, Ajzen extended TRA in 1985 and developed it into the planned behavior theory (Ajzen, 1985). TPB is composed of five factors: attitude, subjective norms, perceived behavior control, willingness, and behavior. Compared with rational behavior theory, it has one more variable of perceived behavior control. The theory holds that the intention of an individual for a specific behavior can directly determine the behavior controlled by individual will, and the behavior intention is determined by the individual's attitude, subjective norms, and perceived behavior control. That is to say, the more positive an individual's attitude towards a specific behavior is, the greater subjective pressure he may feel from the norms, and the more perceptual behavior control he may perform. When the individual's willingness to perform a specific behavior is strong, the specific behavior will be executed accordingly.

Perceived Behavior Control (PBC) is a brand-new concept that refers to "an individual's perception of whether it is easy or difficult to perform a specific behavior" (Ajzen, 1991). It is the perception of the degree of controllability of related factors that promote or hinder the execution of specific behaviors. It depends on the relative weight of costs and benefits involved in the process of accomplishing a certain purpose, such as money cost, labor cost, time cost, and interpersonal communication cost (Lindenberg & Steg, 2007). PBC consists of two components. One is self-efficacy, which means the degree of confidence and ease that a person perceives when performing certain behaviors. The other is controllability, that is, an individual's view of whether the behavior can be fully grasped.

TPB is a typical representative of behavioral process decision theory (Kwon, & Silva, 2020). It has been widely used in behavioral research on sustainability (Banyte et al., 2020). It can explain human behavior in a wide range of environmental cases and is considered to be the most important research theory of green purchasing (Huijts et al., 2014). Even so, it still has some major flaws.

TPB focuses too much on people's rational thinking in the purchasing process. In fact, people may engage in irrational, reckless, and impulsive purchasing. Hence, TPB is not applicable to the analysis of this type of consumer behavior. That pays too much attention to the influence of individuals' subjective psychological factors on their specific behaviors, without taking into account the objective situational factors or environmental factors (external factors).

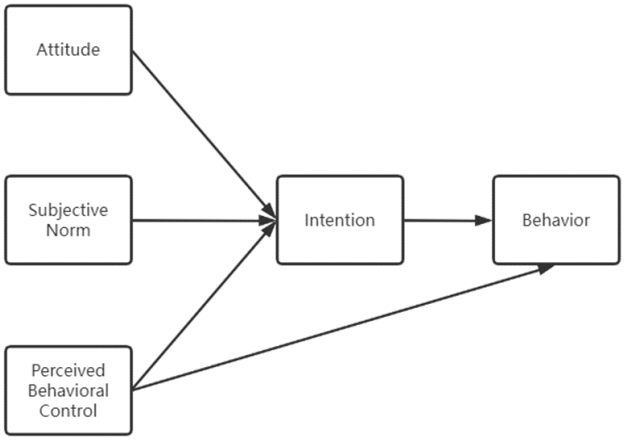


Figure 8: Framework of TPB

CONCLUSION

In conclusion, this research contributes significantly to the understanding of green purchase intention (GPI) from 2017 to 2022 by conducting a systematic literature review (SLR) from multiple perspectives. The study has achieved several key objectives and drawn insightful conclusions.

Firstly, by categorizing influencing factors into internal and external categories, the research highlights the diverse array of factors shaping GPI. Notably, internal factors such as environmental concerns and social influences have received considerable attention, underscoring the complexity of consumer decision-making in sustainable purchasing.

Secondly, the analysis identifies both extensively studied influences, such as environmental issues and social media, as well as underexplored factors like non-governmental organizations and family pressures. This recognition underscores the need for more comprehensive investigations to capture the full spectrum of influences on green purchasing behavior.

Thirdly, the predominance of the Theory of Planned Behavior (TPB) in existing literature raises concerns about neglecting external factors' influence on GPI. The suggestion to employ a mixed theory model in future research endeavors reflects a crucial advancement in understanding the multifaceted nature of consumer behavior toward sustainability.

Moreover, the research identifies gaps in the literature, such as limited studies on the purchasing behavior of rural populations and specific types of green products. By advocating for more inclusive and diverse research approaches, this study paves the way for more comprehensive insights into GPI across various demographic and product categories.

In addition to its empirical contributions, this research holds theoretical significance by advancing our understanding of consumer behavior in the context of sustainability. By synthesizing and analyzing existing knowledge, this study informs future research directions, policy-making, and business strategies aimed at promoting sustainable consumption patterns.

In essence, this research serves as a valuable resource for academics, policymakers, and businesses seeking to navigate the complexities of green purchasing behavior. By shedding light on the diverse influences and dynamics at play, this study contributes to broader efforts to address environmental challenges and promote responsible stewardship of our planet.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

There are some limitations in this research. First, the papers we chose are all from the Scopus database and are in English only, so, they don't cover databases from countries where English is not the primary working language (such as the Chinese-based CNKI database) or all related papers (such as papers in Russian, Chinese, and Japanese). So, in future research, more databases and languages can be included. Second, the papers we collected were all published from 2017 to 2022, so the study period can be extended in future research. Third, due to the limited study scope, there may be some omissions of the influencing factors in the summary, which can be added in future research with larger sample sizes.

The chosen literature investigates the purchase intentions for green products in general, rather than focusing on a specific green product. However, it is also important to distinguish the influencing factors of different products, for example, small commodities and bulk commodities. Researchers can try to study various types of green products in the future, such as purchase intentions for environmentally friendly houses, and green detergents.

Due to the differences in cultural backgrounds, the same influencing factor may have different effects on consumers in different countries, regions, and ethnicities. Therefore, it is necessary to conduct studies on influencing factors of consumer behavior at a national scale, a regional scale or an ethnic scale. In addition, future research can also pay more attention to the influence of external factors on GPI, while studying internal factors.

Furthermore, researchers can combine more purchasing theories or expand them, so as to achieve more comprehensive and accurate research conclusions.

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ENGLISH READING PERFORMANCE, LEARNING INTEREST AND MOTIVATION STATUS IN VOCATIONAL COLLEGE WITHIN GUIZHOU PROVINCE, CHINA

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ABSTRACT

English education encompasses four fundamental skills: listening, speaking, reading, and writing. Reading plays a pivotal role in the acquisition of the English language. While most students acknowledge the significance of English reading, there are still numerous challenges in its practical application. This study employed the English Reading Interest and Motivation Questionnaire along with the Star Reading test to examine the English reading performance, interest, and motivation of 102 freshmen from vocational colleges in Guizhou Province. By conducting descriptive and correlation analyses on the survey results, our aim is to present an overview of the current state of English reading proficiency among students in vocational colleges in Guizhou Province. Furthermore, we seek to analyze existing conditions and contributing factors while proposing corresponding solutions based on an extensive analysis of underlying causes. The objective of this study is to identify factors influencing the current situation regarding English reading among vocational students in Guizhou and suggest appropriate measures through comprehensive research analysis. The findings of this study can assist educators in conducting a more comprehensive analysis of students' sources, formulating appropriate instructional content based on individual student needs, and employing suitable pedagogical approaches to effectively enhance the quality of English reading instruction.

Keywords:
English reading performance, learning interest, motivation, vocational student, English reading status

INTRODUCTION

The English teaching curriculum encompasses four fundamental components: listening, speaking, reading, and writing. Different courses exhibit distinct characteristics. Reading plays a pivotal role in facilitating individuals' effective acquisition of information from external sources. The Vocational Education College English Curriculum Standards (2021 edition) (MOE.PRC, 2021) explicitly emphasize the urgent need to enhance students' proficiency in English reading. To meet these standards, it is essential for grammar professors at the intermediate stage of subject learning to employ various methods such as serial memory blocks to facilitate comprehensive mastery and alleviate vocational students' anxiety towards English reading. This approach aims to cultivate their interest in English reading and ultimately improve their language acquisition and utilization skills (Xiang & Shi, 2022). Through an assessment of the levels of English reading among vocational college students, Liang (2019) discovered that approximately 80% of students failed to reach the passing level. Further analysis of the test content revealed lower scores on more academic text types like argumentative essays compared to narrative essays. Considering the current state of vocational students' performance in English reading, both objective factors and subjective factors contribute to this situation (Liu, 2020). By analyzing the results of an interest and motivation survey as well as an English reading test administered to 102 vocational college students in Guizhou Province, China, this study aims to examine the present state of proficiency in English reading among these students.

RESEARCH QUESTIONS AND RESEARCH OBJECTIVES

Research Questions

There are two research questions in this study, and they are:
(1) What is the current situation of vocational college students' English reading performance, learning interest and motivation in China context?
(2) What factors influence the English reading performance, learning interest, and learning motivation of vocational college students in China?

Research Objectives

(1) To identify the current situation of vocational college students' English reading performance, learning interest and motivation in China context.
(2) To investigate the factors influencing English reading performance, learning interest, and learning motivation among vocational college students in China.

LITERATURE REVIEW

The teaching of reading plays a crucial role in enhancing students' English proficiency, as it facilitates the acquisition of extensive knowledge and enhances their practical application skills. Currently, numerous vocational institutions in China are actively addressing the unscientific practices in English instruction to optimize the effectiveness of language education and foster well-rounded individuals with comprehensive English competence (Wu, 2020). Through a questionnaire survey conducted on two natural science classes comprising of 72 students, Wang (2019) discovered that over 70% of vocational students perceived their English proficiency to be inferior compared to their high school years, and experienced difficulties when engaging in English reading activities upon entering college. Wang asserts that addressing this issue necessitates enhancing students' English reading abilities and modifying the teaching approach. However, it should be noted that the questionnaire survey may not accurately reflect students' actual reading performance. Liang (2019) enhanced this study by employing a questionnaire and test methodology. He administered a questionnaire survey to 264 freshmen across six natural science classes, while also utilizing six reading articles to assess their reading proficiency. Based on the evaluation results, Liang posits that students exhibit competence in comprehending narrative texts compared to argumentative and expository ones. Regrettably, he does not provide further elucidation for this phenomenon. Vocational students exhibit a lack of interest in the pursuit of English language acquisition. This deficiency can be primarily attributed to several key factors pertaining to their approach towards English learning: firstly, disparities exist in terms of proficiency levels; secondly, there is a disconnect between English language instruction and vocational-technical courses; thirdly, the psychology surrounding English language acquisition is distinct (Lei, 2017). The learning motivation of English reading was examined by Fu (2022) using the literature method. He posited that learning motivation played a pivotal role in influencing learning performance, and delving into motivational factors constituted an effective approach to enhancing learning outcomes.

In conclusion, it can be observed from previous research that numerous scholars have partially delineated the English proficiency of students in Chinese vocational colleges; however, an assessment of their reading skills is lacking. Simultaneously, the analysis of current circumstances has often treated interest and motivation for reading as separate entities without delving into their interconnection. Scholars propose a need to re-explore and organize the relationship between motivation, interest, and reading performance in conjunction with contemporary developments while objectively examining the present situation (Fu, 2022; Wu, 2020; Bao, 2021). The research gap lies in the fact that previous studies on students' English reading have examined their reading

performance, reading interest, and learning motivation separately, without integrating these three aspects. This study will employ the motivation and interest questionnaire in conjunction with a professional English reading assessment system to examine the English reading performance, learning interest, and motivation of students enrolled in vocational colleges. Additionally, it will analyze the factors contributing to the current situation.as well.

METHODOLOGY

Methods and Participants

The data collection method of questionnaire survey involves the development of comprehensive questionnaires and the solicitation of respondent answers in accordance with these questionnaires. These questionnaires consist of inquiries that are relevant to the research objective or an investigation form, which are commonly utilized in social research activities for gathering data. Researchers employ this tool to accurately and precisely measure the progression of social activities, applying sociological statistical methods to describe and analyze quantity, thereby obtaining necessary survey data (Xiao, 1995). This study utilized the English Reading Interest and Motivation questionnaire to examine the levels of interest and motivation towards English learning among 102 vocational freshmen in Guizhou, China. Simultaneously, a Star reading test was administered to all participants. The findings from both the reading test and questionnaire were analyzed to assess their English reading performance, learning interest, and motivation. Furthermore, this study aimed to identify the factors influencing their interest, motivation, and performance.

RESEARCH INSTRUMENTS

Questionnaire

In order to assess the current motivation and interests in English reading among Chinese vocational students, this study utilized a Motivations and Interest for English Reading Questionnaire consisting of two parts: personal information about subjects in part one; self-assessment checklist for students in part two. Adapted from Gao's (2003a) proposed questionnaire and Oxford University's Learning Strategies scale (2008), it comprises 60 items presented exclusively in English language format scored on a range from 1 (Not matched.) to 5 (Completely matched).

Star Reading Test

The Lexile Reading measurement system was employed to administer reading performance using the Star Reading test as an assessment tool. The Star Reading English reading ability assessment system, developed by Renaissance Company (Yang, 2021), is a comprehensive and data-driven set of professional graded tests for evaluating English reading proficiency. Its efficacy has been extensively validated through over 400 research studies, garnering recognition from the scientific community. This computer adaptive test dynamically adjusts question difficulty based on students' responses, ensuring precise measurement of their English reading abilities (Byer, 2022).
The reading test report encompassed the tester's Scaled score, alongside the scores obtained in each of the three sections, namely literature, informational text and language.

Data Collection and Analysis

The administration of both the questionnaire and reading comprehension test took place within a classroom setting, where every participant received an individual copy for completion. To ensure optimal subject cooperation as well as a high retrieval rate for both questionnaires and test papers, these materials were promptly collected upon completion. A total distribution count of 102 copies was achieved for each questionnaire/test paper pair, all successfully retrieved. Consequently, our analysis is based solely on valid returns expressed through numerical counts or percentages.

FINDINGS AND DISCUSSION

The present study aims to provide an in-depth analysis of the English reading performance, learning interest, and motivation among students in vocational colleges in Guizhou Province. Additionally, it seeks to explore the underlying factors contributing to these situations.

Findings

Current Situation of Learning Interest

In this study, there are a total of 30 interest-related questions, with an average score of 3.07 points and a standard deviation of 0.88 (see table 1).

Table 1: Findings of interest-related questions

N	Valid	102
	Missing	0
Mean		3.0722
Std. Deviation		.88441

The questionnaire results indicate that 90% of the students demonstrate an awareness of the significance of English reading in language acquisition, yet only 19.6% derive pleasure from it. Another 5.9% exhibit no interest in English reading whatsoever. Simultaneously, despite perceiving English reading as enjoyable (see table 2)

Table 2: Percentage of feeling enjoyable in English reading

		Frequency	Percent	Valid Percent	Cumulative Percent
lid	Not matched	6	5.9	5.9	5.9
	Mostly not matched	24	23.5	23.5	29.4
	Basicly matched	23	22.5	22.5	52.0
	Mostly matched	29	28.4	28.4	80.4
	Completely matched	20	19.6	19.6	100.0
	Total	102	100.0	100.0	

Only a meager 7.8% of students actively participate in independent reading following the completion of assignments given by their instructors. Faced with demanding reading materials, only a paltry 14.7

percent choose to persist and overcome the challenges they present. The atmosphere in the English reading class was deemed unsatisfactory by over 50% of the students. Additionally, over half of the students express feelings of boredom and distraction while engaging in English reading activities. The percentage of students who reported being able to keep pace with their teachers in class was less than 20 percent. Only 8.8% claim to possess the ability to resist external temptations and maintain focus for profound engagement in studying English literature study. Moreover, an overwhelming majority (over 90%) recognize that while engrossed in perusing English texts, they are able to forge personal connections and immerse themselves into a vivid realm. The majority of students in vocational colleges generally exhibit a lack of interest in English reading, while simultaneously expressing a greater demand for more engaging reading materials.

Current Situation of Learning Motivation

In terms of motivation, this questionnaire consists of 30 items pertaining to the motivation for learning English language, with an average score of 3.11 and standard deviation of 0.89.(see table 3)

Table 3: Finding of motivation-related questions

N	Valid	102
	Missing	0
Mean		3.1173
Std. Deviation		.88569

In this questionnaire, only 14.7% of the respondents indicate their proactive engagement in English reading classes, while less than 10% claim independence in previewing materials. Over half of the students express a preference for not being assigned tasks related to English reading. Consequently, without such assignments, most students would not actively pursue English reading activities. Merely 12.7% of those surveyed display enthusiasm towards enrolling in an English reading course. On the other hand, a significant majority (80%) express a desire to enhance their proficiency in English reading skills. Approximately three-quarters of the students indicate a predilection for reading materials pertaining to their individual interests, including topics related to customs and culture. Additionally, an exceedingly high percentage (95%) express a desire for content that directly relates to their academic discipline or prospective career.

In terms of motivational factors, significant contributions are observed from external stimuli like commendation received from educators and parents in conjunction with the potential real-life implications and academic benefits associated with reading activities aimed at enhancing understanding of novel ideas. Concurrently, intrinsic motivators encompassing the development of expressive capabilities, enhancement of logical reasoning skills, and expansionary experiences played pivotal roles in motivating students' engagement in English literature.

Current Situation of Reading Performance

The reading performance test utilized the Star reading test system to evaluate seven English abilities across three sections corresponding to the tester's Level. These abilities include Key Ideas and Details in literature, Range of Reading and Level of Text Complexity; Key Ideas and Details in Information text, Craft and Structure, Integration of Knowledge and Ideas, Range of Reading and Level of Text Complexity; Vocabulary Acquisition and Use in Language. Additionally, the scaled score ranging from 0 to 1400 was provided for each student.

The average scaled score of students on the test is 175.35, indicating a relatively low performance. The highest score achieve was 547, while the lowest score obtained is 74. With a

standard deviation of 96.646, there is considerable variation in student proficiency levels. Students scoring below 100 accounted for 26.6% of the total, those between 100 and 200 accounted for 48.1%, those between 200 and 300 accounted for 17.7%, and only a mere fraction (6.3%) scored above the threshold of 300.

In terms of domain scores (ranging from 0 to99), vocabulary in the language sector attain the highest mean score at38.86. However, craft and structure as well as integration of knowledge and ideas within Information text exhibited comparatively lower scores at20.37and20.91 respectively.(see in table 4).

Table 4: Findings of Star reading test

		ScaledScore	(Literature) Key Ideas and Details	(Literature)Range of Reading and Level of Text Complexity	(Information text) Key Ideas and Details	(Information text) Craft and Structure	(Information text) Integration of Knowledge and Ideas:	(Information text) Range of Reading and Level of Text Complexity	(Language) Vocabulary Acquisition and Use
N	Valid	102	102	102	102	102	102	102	102
	Missing	0	0	0	0	0	0	0	0
Mean		175.35	30.72	28.68	32.25	20.91	20.37	32.42	38.86
Std. Deviation		96.646	20.527	20.551	26.401	18.380	18.063	21.220	21.131
Percentiles	25	90.00	15.00	13.00	12.00	6.00	7.00	16.00	23.00
	50	166.00	29.00	27.00	30.00	18.00	17.00	31.00	40.00
	75	205.00	41.00	38.00	41.00	27.00	25.00	43.00	51.00

Correlations of Factors

We used a Pearson's correlation to understand whether there is an association between learning interest and reading performance. The two variables are interest, measured from 1-5. and reading performance score, measured from 0-1400. (Table 5)

Table 5: Correlations analysis between reading performance and learning interest

		Reading performance	Mean of interest
Reading performancee	Pearson Correlation	1	.833**
	Sig. (2-tailed)		.000
	N	102	102
Mean of interst	Pearson Correlation	.833**	1
	Sig. (2-tailed)	.000	
	N	102	102

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson Correlation figure, which is 0.833 in this case. Pearsons r varies between +1 and -1, where +1 is a perfect positive correlation, and -1 is a perfect negative correlation. 0 means there is no linear correlation at all.

Our figure of 0.833 indicates a very strong positive correlation. The greater the level of interest exhibited by test subjects towards English reading, the great the perform in English reading. And, the strength of the association is strong. $|r|>5$

Were also interested in the 2-tailed significance value-which in this case is <.000. The standard alpha is 0.05, which means that our correlation is highly significance, not just a function of random sampling error.

We employed Pearson's correlation coefficient to examine the presence of a relationship between learning motivation and reading performance. The two variables under investigation include interest, assessed on a scale ranging from 1 to 5, and reading performance score, measured on a scale from 0 to 1400 (refer to Table 6).

Table 6: Correlations analysis between reading performance and learning motivation

		Reading performancee	Mean of motivation
Reading performancee	Pearson Correlation	1	.840**
	Sig. (2-tailed)		.000
	N	102	102
Mean of motivation	Pearson Correlation	.840**	1
	Sig. (2-tailed)	.000	
	N	102	102

**. Correlation is significant at the 0.01 level (2-tailed).

Our correlation coefficient of 0.840 indicates a robust positive association, suggesting that as the level of motivation in English reading increases among test subjects, their performance in English reading also improves significantly. Moreover, the strength of this relationship is substantial ($|r|>5$). Additionally, we observed a highly significant two-tailed p-value (<.000), surpassing the standard alpha level of 0.05 and confirming that our correlation is higher not merely attributable to random sampling error.

After analyzing the data, we have observed a strong correlation between learning interest and learning motivation (refer to Table 7). It is evident that levels of interest lead to greater motivation for learning.

	Mean of motivation	Mean of interst
Pearson Correlation	1	.994**
Sig. (2-tailed)		.000
N	102	102
Pearson Correlation	.994**	1
Sig. (2-tailed)	.000	
N	102	102

DISCUSSION

The aim of this study is to investigate the current state of English reading proficiency, learning interest, and motivation among students in vocational colleges. Our findings indicate that students in vocational colleges exhibit relatively poor English reading skills, with an average score of only 175 out of 1400 points. In terms of specific abilities, due to increased emphasis on vocabulary and grammar instruction by teachers, students tend to perform better in Vocabulary Acquisition and Use skills. However, they face challenges when it comes to comprehending main ideas, details, as well as handling a wide range of texts and complex information. This suggests that vocational students encounter difficulties in information-based reading to some extent.

In terms of students' engagement, majority of the students exhibit disinterest towards English reading; however, if the reading material aligns with their personal interests, this predicament can be ameliorated. Henceforth, it can be inferred that the content of reading materials significantly impacts students' level of interest in reading. Simultaneously, an optimal classroom environment and effective teaching methodologies also contribute to enhancing students' enthusiasm for learning.

The motivation for learning English is weakened in vocational colleges due to its status as a mere public course, which corresponds to the majors pursued by students. Simultaneously, inadequate teaching methods and content exert a negative impact on students' motivation for language acquisition.

Through the analysis, it becomes evident that a significant correlation exists between English reading performance and reading interest and motivation. Enhanced levels of motivation and keen interest among students invariably lead to improved English reading proficiency.

The findings from the questionnaire and reading comprehension test indicate that:

The English reading proficiency of students in vocational colleges is generally subpar.

There are significant variations in the English reading proficiency among students across different sectors within vocational colleges.

Students exhibit low levels of motivation and competence in their reading learning, with extrinsic motivation outweighing intrinsic motivation.

The improvement of English reading performance, reading interest, and motivation among students in vocational colleges can be achieved through the following measures. Firstly, enhancing the teaching mode of English reading to enhance students' independent reading ability is crucial. Chastain (1976) argued that teachers should primarily focus on encouraging students to read by selecting content that aligns with their interests and appropriate language difficulty levels. Additionally, providing specific guidance and planning auxiliary activities are essential components of this approach. Moreover, it is necessary for teachers to shift from the traditional translation and explanation-based teaching mode towards a student-centered approach such as task-based learning. Second, foster students' interest in reading. According to Lindgren's (1991) investigation on the impact of interest on learning outcomes, it was found that interest has a greater influence on learning effectiveness compared to intelligence. By enhancing the classroom content and selecting appropriate materials, the reading course can be made more engaging and captivating. Thirdly, foster students' intrinsic motivation for learning. The significance of learning motivation in education and psychology has long been a prominent research area, exerting a profound impact on the advancement of foreign language teaching and acquisition. Learning motivation is intricately linked to students' learning outcomes as it directly influences their proactive engagement in foreign language learning and their self-assurance in mastering English (Hou & Zhang, 2021). Intrinsic motivation serves as a catalyst for sustained student progress.

CONCLUSION

Based on the aforementioned results and discussions, it can be concluded that students in vocational colleges in Guizhou Province exhibit a low level of English reading proficiency along with limited interest and motivation towards English learning. Three factors have been identified as influencing students' reading performance: (1) teaching methods. The predominant focus of teachers on vocabulary and grammar explanations within reading materials tends to result in a relatively strong grasp of vocabulary and grammar but neglects comprehension and text processing. Furthermore, this pedagogical approach renders reading classes unstimulating for students, leading to a lack of motivation for active learning. (2) Reading materials. The selection of appropriate reading materials directly impacts students' interest and motivation, subsequently affecting their overall reading performance. Therefore, careful consideration must be given to the choice of suitable texts. (3) Students' individual abilities. The varying levels among vocational college students can significantly impact their subsequent performance as well as their interest and motivation towards English reading if their current level is not sufficiently mastered.

To enhance English reading scores, it is recommended to adopt student-centered teaching methods that foster students' interests and motivations for learning while incorporating topics that captivate their attention into the curriculum gradually enhancing enthusiasm for acquiring knowledge. These findings will serve as a valuable reference for adjusting teaching methods and content accordingly. Future research endeavors should focus on aligning appropriate teaching methods with the existing circumstances.

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THE VALUE OF TRADITIONAL ARCHITECTURE AND ITS ENLIGHTENMENT TO CONTEMPORARY ARCHITECTURAL DESIGN

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ABSTRACT

This master's thesis, titled "The Value of Traditional Architecture and its Enlightenment to Contemporary Architectural Design," delves into the significance of traditional architectural forms and their relevance to modern design practices. The study is rooted in the recognition of the diminishing appreciation for traditional architecture amidst rapid urbanization and globalization, posing a critical question regarding its preservation and adaptation. The literature review traces the evolution of traditional Chinese residential architecture, comparing it with global counterparts, and examines survival strategies in contemporary contexts. It further explores cultural and social influences that have shaped traditional residences, alongside preservation and adaptation techniques. Methodologically, the research employs a comprehensive approach, integrating historical analysis, case studies, and comparative methodologies to gather data from various sources. Ethical considerations and study limitations are also discussed. The results highlight key elements and features of traditional residential buildings, showcasing regional case studies to underscore the diversity and richness of traditional architecture. The thesis argues for the integration of traditional residential architecture into modern designs, emphasizing the value of traditional wisdom in addressing contemporary challenges such as sustainability and cultural identity. The study underscores the need for a balanced approach to architectural design, where traditional values are not only preserved but also serve as a source of inspiration for innovative and culturally responsive contemporary architecture. Recommendations for future research include deeper exploration of specific traditional techniques and their potential applications in sustainable building practices.

Keywords:
Traditional Architecture, Contemporary Architectural Design, Sustainable Design

INTRODUCTION

China has a rich history of agricultural civilization, with traditional rural settlements representing the life mode of most Chinese people. These villages are rich in natural resources and have preserved their traditional architecture, which is an important historical relic and carrier of social material and spiritual civilization. Similarly, the large amount of industrial fragments caused by traditional industrial management during the Industrial Revolution is also a relic of history, and it also led to the birth of many abandoned industrial sites and mines. From “Abandoned Tin Mine Opencast Site to Urban Regeneration” the study explores the impact and benefits of industrial land restoration projects and sustainable urban planning. The facilities, buildings and ruins that remain today now face the problem of the necessary harmony with contemporary society. The development of new and more challenging environmental legislation in Malaysia and the public pressure associated with the need to protect the environment increase the need to transform post-industrial sites into multipurpose landscapes. As more industrial sites are transformed into multifunctional landscapes, these projects will not simply become regular ornamental landscape features. The project was transformed into a complex and neat multi-purpose landscape corridor with an artificial lake, bike path, exhibition hall, swimming pool, racetrack, art gallery, park, golf course, shopping center and surrounding landscape amenities. Traditional architecture has significant value and significance in various fields such as history, architecture, art, science, technology, landscape, ecology, aesthetics, philosophy, and more. However, the development of the economy and industrialization has led to threats to traditional architecture, such as natural erosion, artificial damage, and blind construction that does not follow

regional contexts. People's lack of understanding of the value of ancient villages and imperfect existing protection measures has resulted in some traditional architectural resources being demolished, rebuilt, or completely renovated, losing their original vernacular flavor, rural charm, and aesthetic feeling. Urban landscape elements, such as cement roads, have also been incorporated into construction, destroying the original spatial scale and pattern of buildings. In recent years, the tourism industry has favored ancient architectural resources, leading to new challenges to the protection of traditional architecture. Balancing protection and development is crucial for the protection of modern traditional architecture. A win-win situation of "promoting development through protection and promoting protection through development" is essential for preserving the inheritance of Chinese ancient civilization. In China, a large number of traditional dwellings have been kept less and less, which has a great relationship with people's indifference to traditional culture and art. Driven by the trend of international design, traditional architecture has gradually been forgotten by us. However, with the appeal of some designers who love traditional elements, new understanding of traditional architectural dwellings has been put into the process, and the extraction of new elements of traditional architectural dwellings has been made possible.

LITERATURE REVIEW

This study focuses on the adaptability and protection of Chinese traditional residential buildings in a contemporary society. It explores the evolution trajectory of traditional Chinese residential architecture since ancient times, focusing on its unique design philosophy, architectural skills, and dynamic interaction with the social and cultural environment. The study also examines the challenges and opportunities faced by traditional housing in the current process of rapid urbanization and the positioning and value embodiment in modern society. From a cross-cultural perspective, the study places Chinese traditional houses in a global scope for comparative analysis, exploring how traditional buildings in different cultural contexts and geographical environments show their own characteristics and adaptation strategies. This contrast deepens the understanding of traditional housing characteristics and provides multiple perspectives and practical insights for the research.

The study explores the survival and development of Chinese traditional housing in the rapidly changing urban environment, refining the core discovery and theoretical model about the adaptability and sustainability of traditional housing in the contemporary background. Cultural and social factors, such as family structure, lifestyle, and religious belief, shape the form and function of traditional housing, giving them a unique cultural identity and significant impact on their adaptability and vitality in contemporary times. Such as Beijing quadrangle courtyard Fujian Tulou, Water Townhouses in Jiangnan Region, Weilongwu, Lingnan Vernacular Houses in Southern China, Tibetan Stone and Timber Houses. The Siheyuan, or quadrangle courtyard houses, found predominantly in Northern China, epitomize the Confucian hierarchy and the balance between man and nature. The Fujian Tulou of southern China. The water townhouses along the Yangtze River Delta illustrate the harmony between human settlement and waterways. Weilongwu their concentric rings of living spaces radiating from a central courtyard demonstrate effective use of space and efficient ventilation systems. Lingnan Vernacular Houses in Southern China these traditional structures, deeply rooted in local geography and climatic conditions, exhibit a refined balance between functionality and aesthetics that reflects the wisdom and creativity of the Lingnan people. In essence, Tibetan architecture is a living embodiment of resilience and adaptation, encapsulating the deep-rooted wisdom of a culture that has evolved over centuries to live in harmony with its breathtaking yet unforgiving environment. It is a narrative of survival and spiritual sustenance, written in stone, timber, and the unyielding resolve of a people whose existence is intrinsically tied to the majesty of the Himalayas. Technological innovation and practice are discussed, highlighting the latest progress in material science, structural engineering, and energy efficiency to promote the sustainable

development of traditional architecture and the inheritance of cultural heritage from generation to generation. The study aims to highlight the urgency and necessity of research, filling knowledge gaps, and promoting academic progress and practical innovation. This study aimed to understand the conservation and development of traditional Chinese residential architecture through both primary and secondary sources. Primary data was collected through field surveys and interviews with experts, architects, local residents, and authorities involved in the topic. Site visits were essential for firsthand observation and documentation of architectural features, construction techniques, and their current state. Secondary data was obtained from various published and unpublished materials, including books, academic journals, reports, historical documents, and online resources. A structured questionnaire was designed and administered to targeted respondents to gather quantitative and qualitative information about their perceptions, attitudes, and experiences related to the topic. Archival research was conducted to trace the historical development and transformation of these buildings over time. Ethnographic methods were also employed to observe how people interacted with and utilized traditional spaces in contemporary settings. The collected data were meticulously recorded, organized, and systematically analyzed to contribute significantly to achieving the research objectives outlined in Chapter 1. Ethical considerations were strictly adhered to throughout the process, ensuring the privacy and confidentiality of participants and respecting intellectual property rights when using secondary sources. Limitations inherent to data availability, access constraints, and potential biases were acknowledged and addressed as part of the study's methodology.

Primary data collection included field surveys, expert interviews, and community engagement to document the physical attributes, spatial configurations, and structural systems of traditional Chinese residential sites. Secondary data collection included a literature review, archaeological research, and instrumentation and data collection. The comprehensive analysis of the collected data was carried out using a combination of rigorous methodologies and techniques designed to extract meaningful insights and patterns.

RESEARCH METHODOLOGY

This chapter provides a detailed explanation of the research methodology used in this study, which is fundamental to the investigation of traditional Chinese residential architecture. The study also points out that in the process of construction projects, it will inevitably encounter some uncertain factors, which will make the construction projects face many risks. If active measures are not taken to deal with these risks, serious quality problems are likely to occur in the construction project. This will bring huge economic losses and pose a serious threat to the safety of people's lives and property. Therefore, it is very important to strengthen the risk management of construction engineering and construction projects. The methodology includes the selection of appropriate research designs, identification of data sources, instruments and methods used for data collection, and procedures for analyzing the gathered information. The methodology chapter emphasizes the suitability of these methods in addressing the research aims and objectives, as well as answering the research questions posed earlier. It also discusses the alignment of the chosen methodology with the scope and significance of the study, ensuring that the methods are adequate to address the complexities inherent in the topic. The methodology adopted ensures a blend of quantitative and qualitative techniques to achieve a comprehensive understanding of the multifaceted aspects of traditional Chinese residential architecture. It is designed to delve deep into the historical roots, cultural nuances, and practical applications while considering the contemporary demands and possibilities for integration into modern architectural practices. Ethical considerations are taken into account during the research process to ensure the rights of the subjects and the integrity of the data, and it acknowledges the limitations encountered and how they were managed to minimize their impact on the research outcomes. The research design is structured around a mixed-methods approach that combines both

quantitative and qualitative strategies to ensure comprehensive coverage of the subject matter. Quantitatively, the study employs statistical analyses to assess trends, patterns, and correlations within available data sets related to the prevalence, condition, and transformation of traditional houses across different regions in China. Qualitatively, an in-depth analysis of the historical context, cultural nuances, and practical applications of traditional Chinese residential architecture is conducted. Traditional dwellings, born within China's 5000-year cultural heritage, hold significant value in modern architecture and culture dissemination. Huizhou style residential buildings, as representative examples, provide fresh design inspiration for designers and architects. These buildings have profound artistic research value, providing an authentic entity for studying the value of traditional dwellings and understanding their cultural connotations. The academic research value of Huizhou style residential buildings is immeasurable, as they provide authentic and researchable knowledge for understanding ancient architecture. The unique architectural structure and material use in these buildings represent the level of development in architectural techniques at the time. Drawing on good architectural concepts has higher scientific research value for modern design. Traditional residential buildings have become ancient artifacts, and their artistic value in modern times has become an object of appreciation for people. The preservation and inheritance of traditional dwellings can promote the development of the tourism industry, stimulate demand, and promote economic development. Traditional dwellings are immeasurable in terms of enhancing socio-economic value, and new design concepts from traditional living environments are needed to meet people's further needs. The aesthetic value of Huizhou style residential buildings is reflected in their architectural layout, form, and use of colors and materials. The expression of details can further enhance their artistic connotation and charm. Huizhou style residential architecture is different from other residential buildings due to its unique regional characteristics, which often represent the cultural source of the local area.

Hongcun and Xidi, as unique residential buildings in southern Anhui, demonstrate the importance of preserving and preserving traditional dwellings in order to better serve people and drive economic growth.

RESULTS AND DISCUSSION

The development and protection of traditional dwellings should be diversified. Only by overcoming the bottleneck of their own development can China's traditional dwellings enter a new path of development. This new development will bring new design theories and innovative design thinking to the development of modern architecture. Only by means of diversified inheritance can they bring more space for their own development, and also provide enlightening guidance to modern architectural design.The study emphasizes the critical role of residential architecture in shaping communities and influencing societal well-being. Sustainability has led to increased adoption of green technologies, energy-efficient materials, and passive design principles, which not only reduce the carbon footprint of homes but also contribute to improved health and living conditions for occupants. The rise of smart homes and digital integration is transforming how we interact with our living spaces, emphasizing the importance of considering technological advancements in future architectural practices. Universal design principles are essential for creating residential environments that cater to diverse needs and lifestyles across different stages of life. Future architectural practices must prioritize sustainability by integrating renewable energy systems, water conservation methods, and waste management techniques into building designs. Architects should engage in interdisciplinary collaboration with engineers, urban planners, and policymakers to develop holistic and resilient residential solutions. Design education and professional development should emphasize the understanding and application of emerging technologies like AI and IoT in home design. The traditional Malay residence is one of the most unique residential designs in Asia and is of very important Malay heritage. The significance of choosing the traditional Malay residence is that the

traditional residence is closely related to Malaysia as a whole, thus becoming an iconic feature. The Malays hoped that the reference and analysis of this type of house would provide better house design for future generations and what could be learned from the "natural wisdom" of the original traditional Malay house carpenters. In 2008, the number of recorded well-preserved traditional Malay homes is declining and the remains of ancient wisdom are disappearing, a huge loss for the world, and this design concept needs to be passed on. The ingenious ideas of the ancients should incorporate modern ideas. In the study entitles “The Future of Traditional Malay House Design in Peninsular Malaysia:, one of the most famous features of the traditional Malay house, is the "loft field roof", which is made of natural materials. It successfully handled the climate of the tropical country by filtering heat from sunlight, while successfully taking heat from the inside of the house through cross-ventilation of the "iron layer". Policymakers play a pivotal role in shaping the future of residential architecture by encouraging green building codes, offering incentives for sustainable construction, and mandating universal design standards. Urban policies promoting mixed-use developments, social housing schemes, and community-oriented designs can foster more equitable and sustainable neighborhoods. Comprehensive housing policies should address the mismatch between current housing stocks and changing demographics, facilitate renovation of existing buildings to meet modern standards, and incentivize new builds that adhere to sustainable and inclusive design principles. Residential architecture is deeply intertwined with urban planning and community development strategies. Future urban plans should accommodate and encourage a variety of housing types and densities to cater to diverse lifestyles and income levels. Mixed-use developments, community-focused design, and participatory planning processes are key implication.

CONCLUSION

The paper explores the historical significance of traditional Chinese dwellings and their influence on modern architecture. It focuses on the Anhui style residential buildings in southern Anhui, analyzing the overall form and architectural characteristics of Hongcun and Xidi ancient villages. The essence theory of traditional residential design is obtained, which can be integrated into modern architecture by inheriting traditional residential culture. The Huizhou style represents the path of integration between tradition and modernity. The paper concludes that for the preservation or protection of tradition, it should not only remain in the literal sense of "retention" but also be reflected in constantly developing things. Modern architecture should absorb valuable traditional elements and apply them in its own design in the new era, separating the mother body of traditional personality elements and recombine and interpret its essence with new elements. This process requires a balance between tradition and modernity, endowing each with a new personality.

The focus of this paper is to extract and integrate the design ideas of traditional residential buildings in southern Anhui into modern architectural design, implant the essence of tradition into modern architecture, make the development of modern architecture active and traceable, present new design highlights, implant traditional new life elements into modern architectural design, and present historical and cultural connotations in modern architecture. The value of traditional architecture is a treasure trove of wisdom and inspiration for contemporary design, providing a blueprint for sustainable, contextually sensitive, and emotionally resonant design. Modern architecture must draw from the timeless lessons of traditional residential design, embracing its principles of resourcefulness, sustainability, and cultural responsiveness to craft built environments that resonate with both the physical and spiritual world.

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