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A Study of Influential Factors on Engineering Project Records Utilisation Behaviour Based on SEM

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KEYWORDS

Engineering Project Records; Utilisation Behaviour; Structural Equation Modelling; Information Ecology Theory; Engineering Information

ABSTRACT

In the context of sustainable development, the efficient use of engineering project records plays an important role in giving full play to the value of engineering information, solving practical engineering problems, and optimising urban planning and governance. Aiming to address the current issues of low utilisation efficiency and unclear behavioural mechanisms, this study seeks to identify the key factors influencing the utilisation behaviour of engineering project records and their corresponding action paths. Therefore, based on the literature review, this paper combines information ecology theory to construct the "information-human-environment-technology" influencing factor model and uses structural equation modelling (SEM) to conduct empirical research. The study shows that: (1) information facilitation has the most significant impact on the use of engineering project records, highlighting the key role of digital technology in enhancing the efficiency and convenience of archive use. (2) Institutional policy, information quality, information usefulness, information literacy, and information demand all have a positive impact on the use of engineering project records. This study incorporates classical theories into the engineering information flow scenario of engineering project records utilisation, discusses its key factors and paths, and should incorporate a case study and non-linear research methods for more comprehensive research in the future.

INTRODUCTION

In the context of promoting sustainable urban construction and digital transformation, the efficient use of engineering project records, as an important carrier for recording the whole life cycle of engineering projects, is of great significance for reducing resource consumption, optimising urban governance, supporting building operation and maintenance, and resolving engineering disputes. Studies have shown that historical building information models can better serve heritage and cultural relics conservation through "sustainable" workflows and full-cycle documentation (Xu, et al., 2022) and help experts and scholars design better production management systems for construction projects (Sacks & Partouche, 2010). However, in the actual utilisation behaviour, engineering project records are facing multi-

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ple challenges: firstly, the responsibility of all parties of engineering archives is unclear, and the inability to share information leads to the lack of a historical basis for urban renewal and renovation, planning, and construction (Zhu, 2020). Secondly, the lack of technological innovation, the original paper-based utilisation will exacerbate the consumption of resources, and also be unable to enhance the efficiency of the flow of engineering information (Chen, et al., 2024). Thirdly, the lack of engineering project records and irregular collection will directly affect the project quality control and building operation management (Tan, 2025). Although scholars have proposed improvement paths from the perspectives of legal norms and technological innovations, the existing studies are mostly focused on the macro archive field, and there are fewer studies on the use of such records for engineering projects, especially the lack of quantitative analysis of the mechanism of user behaviours, which makes it difficult to achieve accurate and optimized services.

Based on this, this study aims to reveal the key influencing factors and mechanisms of engineering project records utilisation behaviour. By focusing on the engineering project records utilisation behaviour, the essence is to enhance the engineering information flow rate and achieve the sustainable development of engineering information resources. At the theoretical level, the information ecology theory is introduced into the field of engineering archives, and the four-dimensional analysis framework of "information-human-environment-technology" is constructed, which breaks through the limitation of single-factor analyses in the traditional research; at the practical level, 313 engineering practitioners are combined into the study. On the practical level, it combines 313 empirical data points of engineering practitioners to analyse the core elements of utilisation behaviour and provide empirical support for archives to build a hierarchical opening system and an intelligent service platform.

In terms of research methodology, structural equation modelling (SEM) is used for hypothesis testing. The method can deal with the complex relationship between latent and observed variables at the same time, which is especially suitable for analysing the behavioural mechanism of multifactor interaction (Tarka, 2018). In this study, we firstly put forward six hypotheses based on literature analysis and combined with information ecology theory, secondly, we design a scale containing six latent variables and 26 measurement items, collect data through questionnaires, and finally, we use SPSS and AMOS tools to carry out the reliability test, factor analysis, and verification of path relationship.

LITERATURE REVIEWS

Behaviour of Engineering Project Records Utilisation

After combing through the relevant literature, it is found that scholars have carried out research related to the utilisation of engineering project records from different perspectives. From the perspective of law politics: Zhang Juan(2020) believes that one of the reasons for disputes in the process of opening and utilising urban construction archives is the lack of guidance from administrative regulations and other systems; Guo Ruohan(2024) researches the legal requirements for the opening up of urban construction archives using policy textual analyses and practical investigations, and puts forward the paths of solving the problems utilizing guidance from regulations, collaborative governance, and opening up in a classified and hierarchical way; Hu Chaoyang et al.(2009) based on the legitimate rights and interests of all parties of the construction engineering projects, discuss the intellectual property protection in construction and management of engineering projects. Informatisation perspective: Zhao Xia(2024) believes that the water conservancy project archives are faced with problems such as huge amount of information and insufficient utilisation, and urgently needs to introduce modern information technology to promote its management change; Chen Yanjiang et al.(2023) study the construction project vector big data platform, and the functions of this platform such as archive checking and transferring greatly improve the convenience of utilising the project archives; Che Tingting(2020) believes that in the aspect of providing utilisation of the urban construction archives, it is possible to continue to introduce AI, voice recognition, Holograms and other technologies to better achieve the effect of intelligent service experience. From the perspective of information value: Hu Agile(2022) believes that construction information can be used as the basis for claims due to their authenticity and validity; Wang Xiaofang(2023) believes that the relevant knowledge and experience contained in engineering project records can be fully utilised in the innovation of engineering concepts and technologies; Liu Hongzhi(2022) explores the use of grid archives and other information to build a grid project costing resource base, which can be used to assist in the control of cost and accurate decision-making. In summary, scholars from the rule of law, information technology, information value and other perspectives on the use of engineering project records, for the use of engineering project records throughout the link involved in the external system to regulate and guide the use of information technology in the process of service empowerment, as well as the entire use of the value of the information value of the behaviour itself mining attributes to provide a theoretical basis and practical experience.

Influencing Factors of Engineering Project Records Utilisation Behaviour

Based on a comprehensive review of existing literature, current scholarship on influencing factors of archival utilization behavior predominantly concentrates on the archival domain as a whole (Ren et al., 2022; Zhou, 2024). For instance, studies examining public archival utilization behavior typically employ comprehensive archives as research subjects, with identified influencing factors largely encompassing subject-related, object-related, and environmental dimensions (Wu, 2023). Fewer studies discuss the influencing factors by subdividing the types of archives, and the existing studies that subdivided the types of archives include government archives, health archives, academic archives,

urban construction archives, etc. In the research, information theory, behavioural theory, and other related theories are generally adopted to study the influencing factors of archive use behaviour through literature research, interview research, empirical analysis, and other methods. In the research in the field of engineering construction, Zhu Wuqiao(2022) thinks that the data governance capacity of urban construction archives affects the demand for urban construction archives utilisation, so he builds a two-factor matrix theoretical model to explore the relationship between the degree of influence between the two; Chen Hong(2020) thinks that the factors affecting the utilisation of urban construction archives are the archives' factors, such as the resources of the collection, the degree of informatisation, and the staff's professional quality, etc.; the factors of archives utilisers, such as the professional, knowledge background, archival literacy, and social development factors. In summary, the academic community has combined a variety of theories and research methods in the study of factors affecting the overall use of comprehensive archives, and the research results are relatively rich. For the detailed classification of engineering project records, there are only some theoretical studies, but a lack of complete empirical research and data support. Therefore, this paper focuses on the research gap of engineering project records utilisation influencing factors for theoretical and empirical analysis, revealing the mechanism of influencing factors, but also serves as a useful supplement to the research on the use of engineering project records behaviour.

Information Ecology Theory

The concept of "information ecology" was first proposed by Horton (1978) to describe the dynamic and interactive ecological relationship between information and human society. The systematic information ecology theory was proposed by American scholars Nardi and O'Day in their work, which argues that information behaviours are embedded in a complex ecosystem consisting of elements such as information, people, environment, and technology. Among them, the information dimension refers to the type, structure, quality of information resources and their state of flow in the system; the information people include the producers, managers and users of information; the environment dimension refers to the influence of the external environment, such as institutional policy and organisational structure, on information behaviour; and the technological dimension serves as an information medium and support tool, influencing the efficiency and scope of information generation and use. In this theoretical perspective, information is not only a product of technology but also a result of social interaction and institutional arrangement. Different from traditional information technology research, information ecology emphasises the dynamics, synergy, and adaptability of the system, and pays attention to factors such as institutional culture and environment behind information.

At present, the information ecology theory has been widely used in the fields of graphic information, government affairs, education, etc., and has gradually expanded to the research of archive management and project information. Sun and Chai(2025) take the information ecology theory as the perspective, and build the archive open ecosystem model with the four corresponding dimensions of theme-driven, information supply-demand, technological empowerment, and institutional policy, to explore the establishment of the archive opening incentive mechanism in archives. Hu Bin (2023), based on the perspective of the information ecological chain, combined with the multi-attribute characteristics of technology-time-space-responsibility-resource of information factor and interface management, constructed a multi-attribute interface maturity evaluation system for rail transit construction projects, and conducted comparative analyses of maturity in various stages and dimensions. Hu Hongfei (2025) starts from the perspective of information ecology, screens the influencing factors affecting the information transfer efficiency of the assembly building supply chain, and summarises 21 influencing factors in 4 dimensions, namely, information attributes, information subject, information environment, and information transfer medium.

Therefore, the information ecology theory gives us a comprehensive research perspective for explaining the operation mechanism of complex socio-technical systems such as information technology applications, information resource transfer, and information collaboration.

RESEARCH ASSUMPTIONS AND MODEL CONSTRUCTION

Research Assumptions

Information Factor Hypothesis

In this study, the information dimension mainly refers to the two aspects of information quality and information usefulness of engineering project records. The information quality of engineering project records is determined by the completeness and authenticity of information. Completeness is that engineering project records completely record all the project information of a project in the whole process from planning and design to completion and acceptance, and in terms of the form of records, the records in various forms such as text, pictures, sound, and image should also be complete. Authenticity is reflected in the objectivity and originality of the information in the engineering project records; the definition of the file itself determines its true and objective characteristics, without any false information. The more true and objective information in the engineering project records, the greater the value of the use of archives. Therefore, the integrity and authenticity of these two aspects of the characteristics of the engineering project records provide the user with high-quality information, and the user is also more inclined to use it. The usefulness of information is the user's subjective judgement of the usefulness of the information, in the context of the use of engineering project records. Usefulness refers to the use of engineering project records as a reference to deal with engineering planning, claims disputes, quality audits, and other effective work. When users believe that they can solve the problems in their

work by using engineering project records, they will have the corresponding willingness to use them, and then the use behaviour will occur.

Based on the above analysis, the hypothesis is proposed:

1) The quality of engineering project information positively affects the use behaviour.
2) The usefulness of engineering project information positively affects the use behaviour.

Hypothesis of Informant Factor

Information ecology theory emphasises that "information people" are the facilitators of information flow in the information ecosystem, and the information literacy and information needs of users directly affect the efficiency of information flow and utilisation (Liu et al., 2022; Zhang, 2018). The information literacy of users means that users can accurately identify their own information needs, understand the ways of archive search, including online and offline archive search methods, archive search process, and be able to assess the relevance of archives to the information they need with their engineering knowledge, as well as assess the reliability and usefulness of archives themselves. Users with good information literacy can clarify the type and structure of information resources provided by archives, accurately assess the value of archives, so that they are more confident and capable of solving their work problems with archives, and the frequency and depth of their utilisation behaviours tend to increase. Information demand refers to the user's subjective desire for information in the process of completing a specific task or solving a problem, which can be understood in the engineering field as the user's subjective demand for information on engineering project records in engineering management, technological innovation, and compliance review. User demand includes the task-driven demand for accessing archives during project acceptance, and the development-driven demand for mining technical experience in engineering archives during technological innovation. Clear information needs can help users express their demands more accurately, improve retrieval efficiency, and facilitate the use of behaviour. In summary, user information literacy and user information needs are taken as informative factors.

Based on the above analysis, the hypothesis is proposed:

3) User information literacy positively influences utilisation behaviour
4) User information needs positively influence utilisation behaviour

Information Environment Factor Hypothesis

In the information ecology theory, the environmental dimension emphasises the external environmental conditions on which the information system relies for survival and development, and the environmental factors have strong social attributes and are the key elements that limit human behaviour. In the environmental dimension, the institutional environment plays a fundamental and framework role, and the institutional policy sets the fundamental rules and boundaries for the flow, access, and use of information resources. Kong(2003) points out that the "environment" in the information ecology not only includes external conditions such as organizational system and technical support, but also covers external conditions such as information policy, Kong points out that the "environment" in information ecosystem not only includes external conditions such as organizational system, technical support, information policy, but also soft environment factors such as cultural atmosphere and organizational norms. This paper combines the theory of information ecology to study the information environment and information technology factors separately. Since engineering project records often involve public interests and project safety, and the project information contains engineering design, construction technology patents, and other intellectual property-related content that needs to be kept confidential, the management, opening, and use of engineering project records are subject to strict legal constraints. At the same time, engineering projects have many participants and complex sources of archives, and their utilisation process needs clear and unified rules to guide (Guo, 2024). Therefore, this paper combines the relevant discussions on the external environmental factors of construction archive information utilisation, and regards the influence of institutional policies as the main environmental factor.

Based on the above analysis, the hypothesis is proposed:

5) Institutional policy factors of engineering project records positively influence utilisation behaviour.

Hypothesis of Information Technology Factors

The technology factor is the key to supporting the efficient operation of the information ecosystem, especially in the context of digitisation. Information technology provides technical support for the collection, storage, and use of engineering project information, and also makes the whole records management work more scientific and comprehensive, and the process of utilisation services more efficient and convenient. This study focuses on the functionality played by the technology itself in this aspect of engineering project records utilisation, i.e., the application of technologies such as big data analysis, BIM, GIS integration, etc., to achieve the enhancement of the service capability, which plays an obvious role in promoting its utilisation behaviour. For example, the engineering vector big data platform developed by Gansu State Grid (Chen & Wang, 2023), compared with the previous file borrowing and approval process, this platform creates a "palm" service utilisation method, which allows users to access the files after being authorised to do so without having to go through the approval process. In addition, its "one-click archive search, one-click map" function makes the user to use the degree of convenience significantly improved, but also solved the long-standing engineering archives difficult to use the problem. The empowering effect of this technology does not depend on the subjective percep-

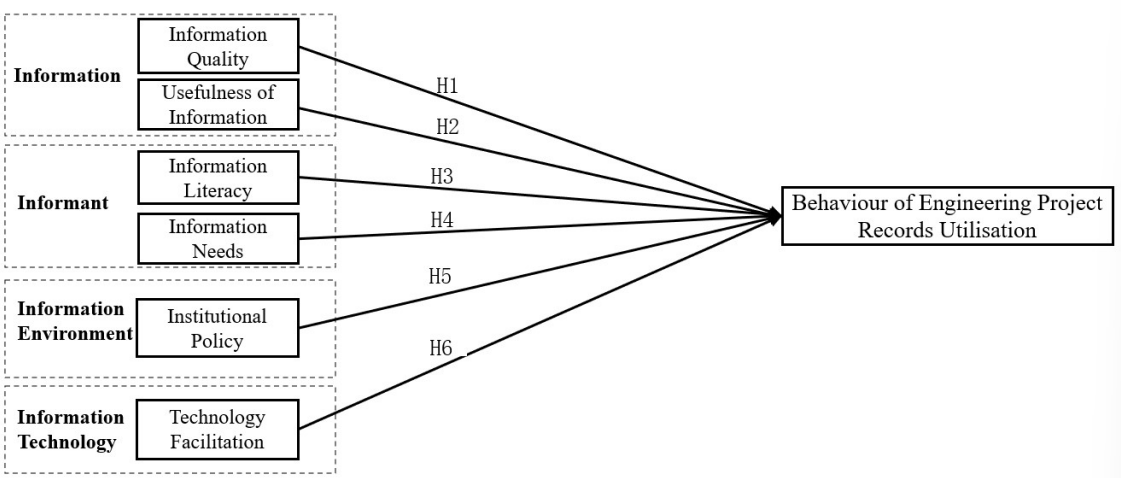

Figure 1 | The hypothetical model of influencing factors of engineering project records utilisation behaviour

tion of users, but originates from the objective functional promotion.

Based on the above analysis, the following hypotheses are proposed:

6) The facilitative nature of information technology positively influences utilisation behaviour.

Model Construction

Combining the information ecology theory analysed above and the relevant assumptions on the influencing factors of engineering project records utilisation behaviour, the hypothetical model of influencing factors of engineering project records utilisation behaviour is constructed as shown in **Figure 1**.

EMPIRICAL ANALYSIS

Questionnaire Design and Variable Measurement

According to the latent variables proposed in the previous content, this study sets the latent variables with reference to the research scales of relevant scholars at home and abroad, and combines with the information ecology theory model to construct the variable measurement scale of the influencing factors of engineering project records utilisation behaviour. Before the formal collection of data, an advanced pre-survey was conducted. According to the results of the pre-survey on the scale for modification and screening, the final scale is determined as shown in **Table 1**. In this paper, the sample data were collected through a questionnaire survey, and the observed variables in the questionnaire were based on a 5-point Likert scale, with the options consisting of "Strongly Agree", "Agree", "Generally", "Disagree", and "Strongly Disagree". "Disagree" and "Strongly Disagree", corresponding to 5, 4, 3, 2, and 1 point, respectively.

Data Collection

The questionnaire data was collected from the beginning of June 2025 and distributed through platforms such as Questionnaire Star, and the target respondents were those who had been engaged in design, construction management, supervision, engineering auditors and owner's representatives in the field of engineering and who had been involved in types of engineering projects such as housing construction, transport engineering, energy engineering, municipal engineering and so on. In addition, other personnel with experience in the use of engineering project records and experts from university research institutions are also included. A total of 392 questionnaires were collected by the end of June, and the sample data were cleaned to exclude invalid questionnaires with characteristics such as missing values, outliers, abnormal filling time, and regularity of answers, etc., so that a total of 313 valid sample questionnaires were finally determined, and the effective rate of sample recovery was 79.8%. SPSS24.0 and AMOS24.0 software were used to analyse the valid sample data and to verify the hypothesis model of this study.

Reliability Test and Factor Analysis

Reliability Analysis

This study is to measure the main factors by means of scales, so it is necessary to test the data quality of the measurement results, which is an important prerequisite to ensure that the subsequent analyses are carried out smoothly. The internal consistency of the data for each variable was tested through Cronbach's Alpha coefficient. In this study, SPSS 24.0 software was used to conduct reliability analysis, and the results of the analysis are shown in **Table 2**, the Cronbach's Alpha coefficients of the seven variables are in the range of 0.8-1, which indicates that the scale used in this study has good internal consistency, good reliability, and does not need to adjust the structure of the questionnaire.

Exploratory Factor Analysis

The influencing factors in this study are constructed according to relevant theories and conventional logic. Whether the measurement items of the observed variables can explain the latent variables of their corresponding dimensions needs to be scientifically tested,

Table 1 | Scale design for the analysis of factors influencing the behaviour of engineering project records use

Latent variable	Question item	Measurement items	Source
Information quality	A1	Engineering project records completely record the information of the whole process from planning to acceptance.	Hu Minjie(2022)
	A2	Engineering project records contain complete information in the form of text, drawings, pictures, sound, and video.	
	A3	The information in the engineering project records is objective and true, and has not been adulterated with false content.	Wang Xiaofang(2023)
	A4	The originality of engineering project records gives them a high degree of credibility.	
Usefulness of information	B1	The information on engineering project records that I have enquired about is useful for my study or work.	Xue Rui(2023)
	B2	Using the information on engineering project records helps to solve the problems encountered in my study or work.	Deng Shengli(2016)
	B3	Using engineering project records can improve my study or work efficiency	
	B4	Using engineering project records enables me to get the information I want	
Information Literacy	C1	I know what kind of information I need to search for in engineering project records.	Yan Liu(2022)
	C2	I have a certain degree of ability to search for archival information	Chen Hong(2020)
	C3	I can accurately judge which engineering project records are relevant to my study or work needs.	Cao Yue(2022)
	C4	I can judge the reliability and usefulness of information in engineering project records in the context of my engineering expertise.	
Information Needs	D1	I want to make use of the information I need about engineering project records.	Zhang Jinzhao(2018)
	D2	I often need to use the engineering project records in my study or work because of task requirements.	Wilson(2000)
	D3	I need to use the archives for developmental purposes, such as engineering and technical innovations.	
	D4	I often need to use the information in the engineering project records to solve problems in my study or work.	
Institutional policy	E1	The policy of opening archives is helpful for the use of the engineering project records.	Sun Dadong(2025)
	E2	Government-issued regulations on access to urban construction archives help access to archives.	Zhang Juan(2020)
	E3	I think clarifying the scope of openness of engineering project records helps archive utilisation.	Guo Ruohan(2024)
	E4	I think clarifying the access and approval process of engineering project records is helpful for archive access.	
	E5	I think that establishing an information security protection system will help the use of construction records.	
Technology facilitation	F1	I think the online archive search function helps the use of engineering project records.	Chen Yanjiang(2023)
	F2	I think the application of information technology can optimize the process of searching engineering project records.	Che Tingting(2020)
	F3	I think that information technology can make access to engineering project records not limited by time and place.	
	F4	The application of information technology can help me quickly find the information I need about engineering project records.	
	F5	I think the application of information technology can achieve accurate retrieval to a certain extent.	
Utilisation behaviour	Y1	I will take the initiative to use engineering project records in my study or work.	Zhang Jinzhao(2018)
	Y2	I will use the engineering project records online or offline.	Davis (1989)
	Y3	I will deal with problems in my study or work by using the information in the engineering project records.	
	Y4	I will make more use of engineering project records to solve problems in my study or work in the future.	

Table 2 | Reliability test

Variable	Cronbach's coefficient	Number of items
Quality of information	0.869	4
Information usefulness	0.902	4
Information Literacy	0.890	4
Information needs	0.887	4
Institutional policies	0.899	5
Technology facilitative	0.876	5
Utilisation behaviour	0.843	4

Table 3 | KMO and Bartlett test

KMO Number of Sampling Suitability	Bartlett's test of sphericity		
	Approximate chi-square	Degree of freedom	Significance
0.878	4785.194	325	0.000

Table 4 | Component matrix after rotation

	Component					
	1	2	3	4	5	6
E5	0.836					
E1	0.824					
E4	0.814					
E3	0.806					
E2	0.797					
F3		0.820				
F4		0.819				
F2		0.788				
F5		0.785				
F1		0.766				
B4			0.872			
B2			0.858			
B3			0.843			
B1			0.838			
C1				0.859		
C3				0.842		
C4				0.826		
C2				0.823		
D3					0.846	
D2					0.828	
D1					0.825	
D4					0.811	
A3						0.828
A2						0.827
A1						0.810
A4						0.805

and at this time, exploratory factor analysis needs to be conducted to test the reasonableness of the measurement items of each observed variable. Before doing factor analysis, KMO and Bartlett's Sphericity Test are needed to check whether the question naire data are suitable for factor analysis. Based on the questionnaire data, the analysis was carried out using SPSS 24.0 software, and the results are shown in **Table 3.** The KMO value is 0.878>0.6, and in Bartlett's spherical test, the degree of freedom is 0.325, and the P-value is 0.000<0.05. The results of the test have met the standard, and the next factor analysis can be carried out.

In the exploratory factor analysis, six common factors were identified and extracted using principal component analysis with an eigenvalue greater than 1 as the criterion. The results of the factor analysis showed that the total variance explained by these six factors cumulatively reached 73.143%, indicating that 73.143% of the total variance could be explained and that the data had an extremely strong explanatory power. The principal component matrix after rotation is shown in **Table 4**, and the factor loading values of all variables after rotation are greater than 0.5. The results of the reliability test have met the standard, indicating that the data are suitable for the next step of factor analysis.

Validation Factor Analysis

In this study, AMOS 24.0 software was used to construct a structural equation model of the factors influencing archival access behaviour, and the reliability and validity of the measurement model were tested by the validated factor model fitness test, convergent validity, composite reliability, and discriminant validity.

CFA model fit test The fitness of the structural equation model was generally measured by the absolute fit index and relative fit index, and the results of the measurements are shown in **Table 5**. The CMIN/DF was 1.328, which is in the range of 1-3, indicating that the measurements are satisfactory. The RMSEA was 0.038, which is in the range of less than 0.05 of excellence.

Table 5 | CFA model fitness test

CMIN/DF	RMSEA	NFI	RFI	IFI	TLI	CFI
1.328	0.026	0.026	0.909	0.985	0.983	0.985

Table 6 | Convergent validity and combined reliability test

Observed Variables	Item	Estimate	AVE	CR
Quality of Information	A1	0.774	0.625	0.8696
	A2	0.803		
	A3	0.814		
	A4	0.771		
Information Usefulness	B1	0.806	0.697	0.902
	B2	0.847		
	B3	0.831		
	B4	0.856		
Information Literacy	C1	0.833	0.669	0.89
	C2	0.799		
	C3	0.842		
	C4	0.799		
Information Requirement	D1	0.821	0.664	0.888
	D2	0.808		
	D3	0.835		
	D4	0.797		
Institutional Policy	E1	0.786	0.642	0.899
	E2	0.78		
	E3	0.784		
	E4	0.799		
	E5	0.857		
Technology Facilitation	F1	0.760	0.586	0.876
	F2	0.749		
	F3	0.797		
	F4	0.769		
	F5	0.752		
Utilisation Behaviour	Y1	0.692	0.577	0.845
	Y2	0.776		
	Y3	0.795		
	Y4	0.773		

The other tests of NFI, RFI, IFI, TLI, and CFI all reached an excellent level of 0.9 or more. Therefore, the comprehensive results of this analysis indicate that the model of factors influencing the behaviour of engineering project records utilisation has good fitness and passed the structural validity test.

Convergent Validity and Combined Reliability Tests Under the precondition that the CFA model has a good fit, the consistency of the latent variables within the scale needs to be tested by measuring the convergent validity and composite reliability of each dimension of the scale. The CFA model is used to calculate the standardised factor loadings of each measurement item in the corresponding dimension, where the standardised factor loadings should be greater than 0.5, and then the convergent validity and composite reliability of each dimension are calculated by using the formula of AVE and CR. According to the standard, the scale can only have good convergent validity and combinatorial reliability if the value of AVE is greater than 0.5 and the value of CR is greater than 0.7. The scale has good convergent validity and combinatorial reliability. According to the test results in **Table 6**, it can be seen that in this validity test, the standardised factor loadings of each observed variable have reached more than 0.5, the AVE values have reached more than 0.5, and the CR values have reached more than 0.7, which comprehensively shows that all dimensions have good convergent validity and combinatorial reliability.

Test of discriminant validity The results of the discriminant validity test are shown in **Table 7**, the discriminant validity is tested by comparing the square root of the AVE value of each latent variable and the correlation coefficients between each latent variable and each

Table 7 | Distinguishing validity test of variables

Variables	Information Quality	Information Usefulness	Information Literacy	Information Needs	Institutional Policy	Technology Facilitation	Utilisation Behaviour
Information Quality	0.625						
Information Usefulness	0.279	0.697					
Information Literacy	0.310	0.317	0.669				
Information Needs	0.327	0.273	0.278	0.664			
Institutional Policy	0.353	0.244	0.324	0.386	0.642		
Technology Facilitation	0.254	0.293	0.266	0.348	0.271	0.586	
Utilisation Behaviour	0.541	0.489	0.488	0.523	0.552	0.530	0.577
Square root of AVE Value	0.791	0.835	0.818	0.815	0.801	0.766	0.760

Note: AVE values are in bold type.

latent variable, if the correlation coefficients between each latent variable and each latent variable are smaller than the square root of the AVE value, it means that each latent variable can measure different information dimensions from the others, and that there is a good discriminant validity between the variables. According to the calculation results in Table 7, the correlation coefficients between each latent variable and other variables are less than the square root of the AVE of each latent variable, which indicates that the hypothetical model of the influencing factors of the behavioural aspects of the use of engineering project records passes the test of discriminant validity.

Structural Equation Model Fitting

The data are imported into AMOS 24.0 to establish the structural equation diagram of the hypothetical model of factors influencing the behaviour of engineering project records utilisation, and the model fitting effect is shown in **Figure 2**. As can be seen from the figure, the overall fit of the structural equation model of the hypothetical model of engineering project records utilisation behavioural influencing factors is good.

The path standardized coefficient of the structural equation model reflects the significance of the role of the path between each variable, and the C.R. value is the ratio of the parameter estimates to the standard error (S.E.), which can be used for significance judgement. The larger the absolute value of C.R., the more significant the path relationship is, and when the absolute value of C.R. is greater than 1.95, it is considered to be a significant difference at the 0.05 level of significance. The results of the specific hypothesis path test are shown in **Table 8**. According to the analysis results, it can be seen that the standardized path coefficient values of information quality, information usefulness, information literacy, information demand, institutional policy, and technological facilitation are 0.234, 0.195, 0.165, 0.171, 0.235, and 0.246, respectively, which indicates that all five factors positively affect the use behaviour of the engineering project records. According to the test results, all six variables of this model are significant at a 95% confidence interval, which indicates that these six factors are the key influences affecting the utilisation behaviour of engineering project records. In addition, the results of the path hypothesis test indicated that H1 to H6 were all valid, which proved the reasonableness of the hypotheses proposed, and also verified the hypothetical model of factors influencing the utilisation behaviour of engineering project records proposed in the previous section.

CONCLUSION AND OUTLOOK

Research Conclusion

Based on the literature research, this paper combines the information ecology theory and constructs a hypothetical model of the factors influencing the utilisation behaviour of engineering project records. Based on the 313 valid data points obtained from the questionnaire survey, structural equation modelling was used to study the path relationship between the factors and reveal the core influence mechanism of engineering project records utilisation behaviour. The results of the study show that: **(1)** According to the results of the significance test, the six latent variables constructed in this study, information quality, information usefulness, information literacy, information needs, institutional policy, and technology facilitation, are all key influencing factors affecting engineering project records utilisation behaviour. **(2)** The results of the model hypothesis path test show that the path coefficient of technological facilitation is the highest, 0.246, which is the primary influencing factor, indicating that the application of informa-

Table 8 | Results of Path Hypothesis Testing of Structural Equation Modelling

Hypothesis	Path Relationship	Estimate	S.E.	C.R.	P	Conclusion
H1	Information Quality → Utilisation Behaviour	0.234	0.046	4.234	***	Established
H2	Information Usefulness → Utilisation Behaviour	0.195	0.041	3.744	***	Established
H3	Information Literacy → Utilisation Behaviour	0.165	0.041	3.132	0.002	Established
H4	Information Demand → Utilisation Behaviour	0.171	0.043	3.122	0.002	Established
H5	Institutional Policy →Utilisation Behaviour	0.235	0.049	4.247	***	Established
H6	Technology Facilitation → Utilisation Behaviour	0.246	0.047	4.506	***	Established

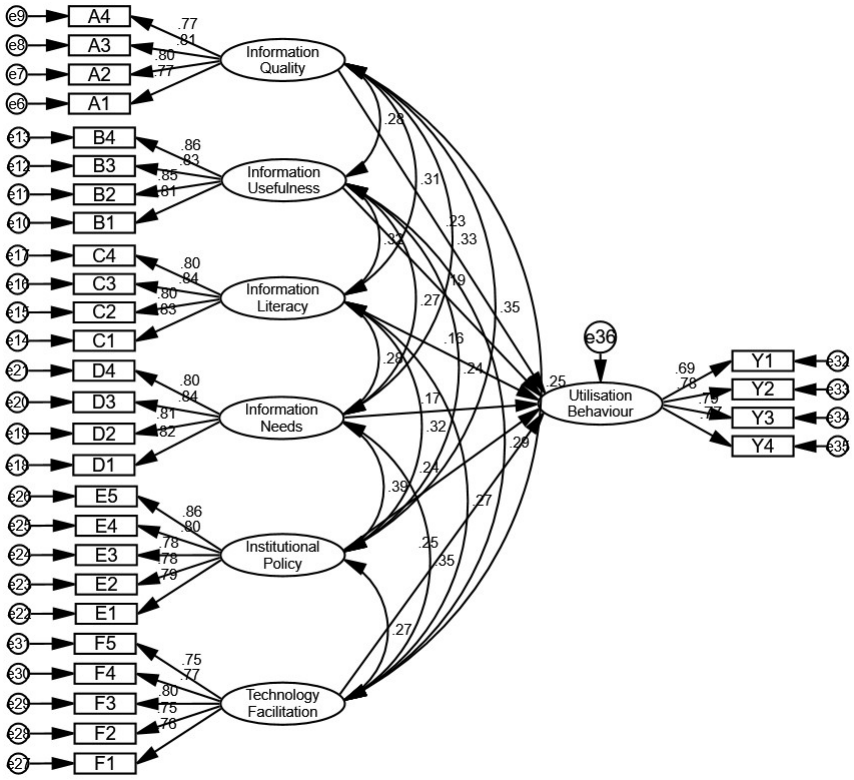

Figure 2 | The model fitting effect

tion technology such as on-line archive search, intelligent retrieval, and e-records has a significant facilitating effect on the utilisation of engineering project records, and can break the temporal and spatial limitations with its functional characteristics; comparing with the traditional paper utilisation mode, the access to the archives is more efficient after the e-accession, and can support more real-time decision-making needs. **(3)** The path coefficient of institutional policy is 0.235, which highlights the special nature of engineering archives, which is different from ordinary archives, because some engineering project records are related to intellectual property rights and public security, and their utilisation is highly dependent on the scope of opening up to the outside world and the formulation of open boundaries of institutional policy, which also explains why the "clear scope of opening up of archives" has become the most important concern of users. This also explains why "clarifying the scope of openness of archives" has become the most concerning institutional element for users. **(4)** Information quality and information usefulness together constitute two variables of the information dimension, with path coefficients of 0.234 and 0.195, respectively, and these two factors together constitute the information basis of access behaviour. The reason why the information factor is not the primary influencing factor is that the engineering project records itself is characterised by authenticity, completeness, and systematicity, and people have a high level of trust in them and do not need to spend energy on screening the authenticity of the information. The completeness and authenticity of the engineering project records directly affect the reliability of building operation and maintenance, engineering dispute handling, and historical data tracing, while the usefulness reinforces the users' willingness to use it by supporting scenarios such as quality review and engineering audit. **(5)** Information literacy and information demand comprise the latent variables of the informant dimension, with path coefficients of 0.165 and 0.171, respectively. User information literacy influences in-depth utilisation behaviours by enhancing the ability to judge the value of archives, while user in-

formation demand promotes utilisation behaviours through task demand and development demand, and the stronger the demand, the more the utilisation behaviours are driven.

The use of engineering project records is essentially a sustainable knowledge flow process driven by the three elements of information, system, and technology. Information technology through the establishment of online data platform, the development of functional interfaces adapted to the needs of users to use, reduce access to time, energy costs directly enhance the efficiency of the use, while the system policy through a balance between the scope of openness and the need for confidentiality to safeguard the legitimacy of the use of the behaviour, the two together promote the sustainability of the flow of engineering information.

Research Outlook

Theoretically, this study expands the application boundary of information ecology theory, and empirically proves that the four-dimensional framework of "information-human-environment-technology" is not only applicable to general fields such as map information and government affairs, but also effectively explains the concept of "multi-party collaboration", "information lifecycle management", and "information management". "On the other hand, it reveals the two-way influence mechanism of institutional policy, and the study finds that the intensity of the influence of institutional environment is higher in the field of engineering archives, which stems from the fact that engineering project records need to safeguard the public's right to know as well as the protection of engineering secrets. In practice: to provide an optimal direction for the open use of engineering project records, urban construction archives can develop an integrated platform at the technical level, embedded with BIM, GIS three-dimensional visualisation functions, to support the full cycle of data traceability of engineering projects; policy makers need to improve the implementation rules for the open use of engineering project records to clarify the scope of confidentiality and the scope of openness, but also to formulate a policy to promote the e-use of engineering archives as soon as possible to achieve the reduction of Paper resource loss, to achieve the sustainability of low-carbon governance; engineering construction parties need to standardise the standard of archiving engineering data, to protect the quality of information from the source.

The use of engineering project records is subject to multiple constraints. Although this study systematically analyses the influencing factors of engineering project records utilisation behaviour, there are still limitations. Firstly, the study mainly focuses on currently known influencing factors and fails to comprehensively cover all possible latent variables. In addition, there may be limitations in the research methodology and research data. The research methodology only adopts literature analysis, questionnaire survey and SEM model analysis, and the questionnaire survey relies on the subjective cognition and recollection of the respondents, which may have information bias; SEM, although capable of verifying the linear relationship between the variables, is insufficient in interpreting the complex non-linear relationship between the variables and the group effect of multiple factors. Therefore, on the basis of exploring the influencing factors, future research should incorporate more latent variables, further improve the influencing factor variable system, introduce mediator variables, and study the influencing mechanism between factors in depth. At the same time, a variety of research methods should be comprehensively applied, case study method should be introduced to deeply analyse the whole process of archive utilisation in typical engineering projects, and fuzzy set qualitative comparative analysis (fsQCA) should be applied to explore the influence of different groupings formed by combinations of factors on the utilisation of engineering project records, and to reveal causal relationships in complex scenarios.

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