

Supplemental Materials

Table S1. Initial screening of key practices

Serial number	Key practices based on literature screening	Key practices based on normative screening	Treatment	Disposal results
1	Extent of application of BIM functionality [31]		Reservations	Extent of application of BIM functionality [31]
2	BIM collaborative design [33]		Reservations	BIM collaborative design [33]
3	BIM precast splitting [35]		Reservations	BIM precast splitting [35]
4	BIM modeling depth [37]		Reservations	BIM modeling depth [37]
5	BIM deepening design [1]	Deepen the design [30]	Incorporation	BIM deepening design [1]
6	BIM software data interactivity [41]	Data interface standard [30]	Incorporation	BIM software data interactivity [41]
7	Standardized and universal design of components [43]			Standardized and universal design of components [43]
8	Intelligent component production line [44]	Automated manufacturing [30]	Incorporation	Intelligent component production line [44]
9	BIM-based scheduling [45]		Reservations	BIM-based scheduling [45]
10	Component transportation costs, route optimization [46]		Reservations	Component transportation costs, route optimization [46]
11	IoT technology for component information collection and quality traceability [47]	Traceability of components [30]	Incorporation	IoT technology for component information collection and quality traceability [47]
12	Visualization of technical briefings [48]	Component organization management [30]	Removing	Visualization of technical briefings [48]
13	Construction site dynamic layout simulation [49]		Reservations	Construction site dynamic layout simulation [49]
14	4D virtual build construction solution optimization [50]	BIM Construction Simulation [30]	Incorporation	4D virtual build construction solution optimization [50]
15	Progress simulation optimization [52]	Progress management [30]	Incorporation	Progress simulation optimization [52]
16	Deformation monitoring informatization [11]		Reservations	Deformation monitoring informatization [11]
17	Automated monitoring of deep foundation pits and adjacent edges [54]		Reservations	Automated monitoring of deep foundation pits and adjacent edges [54]

18	Intelligent grouting and lifting equipment [55,56]		Reservations	Intelligent grouting and lifting equipment [55,56]
19	Robotic applications such as construction robotics and autonomous measuring robotics, etc. [18]		Reservations	Robotic applications such as construction robotics and autonomous measuring robotics, etc.[18]
20	Training and education of VR safety [58]	Security education management [30]	Incorporation	Training and education of VR safety [58]
21	Personnel security behavior monitoring [59]	Video surveillance[30]	Incorporation	Personnel security behavior monitoring [59]
22	System for determining the real name of laborers [60]	System for identifying users [30]	Incorporation	System for determining the real name of laborers [60]
23		Attendance management [30]	Reservations	Attendance management [30]
24		Wage regulation [30]	Reservations	Wage regulation [30]
25		Statistical analysis of labour force data [30]	Reservations	Statistical analysis of labour force data [30]
26	Stockpile planning [32]	Material identification and location [30]	Incorporation	Stockpile planning [32]
27	A system for engineering resource management [34]	Material whole process supervision platform [30]	Incorporation	A system for engineering resource management [34]
28	Monitoring of large equipment safety operations [36]	Equipment intelligent scheduling management [30]	Incorporation	Monitoring of large equipment safety operations [36]
29	Management of Scaffolding engineering informationization safety [38]		Reservations	Management of Scaffolding engineering informationization safety [38]
30	Monitoring of on-site noise and dust informationization [39,40]		Reservations	Monitoring of on-site noise and dust informationization [39,40]
31	Linkage applications for dust reduction, noise reduction and haze reduction [42]		Reservations	Linkage applications for dust reduction, noise reduction and haze reduction [42]
32		Identification of construction waste vehicles [30]	Reservations	Identification of construction waste vehicles [30]
33		Identification and classification of construction waste [30]	Reservations	Identification and classification of construction waste [30]

34		Platforms for monitoring and management of construction waste [30]	Reservations	Platforms for monitoring and management of construction waste [30]
35		Project cost data acquisition model [30]	Reservations	Project cost data acquisition model [30]
36		An Aanalysis model for Price indicator correlation [30]	Reservations	An Aanalysis model for Price indicator correlation [30]
37		Visualization and analysis of project cost [30]	Reservations	Visualization and analysis of project cost [30]
38		Platforms for cloud procurement services [30]	Reservations	Platforms for cloud procurement services [30]
39	Contract informatization management [51]		Reservations	Contract informatization management [51]
40	Platform for engineering collaborative management [53]	Collaborative management information platform [30]	Incorporation	Platform for engineering collaborative management [53]
		Data integration and sharing [30]	Removing	
		Safety and quality management [30]	Removing	
41		System integration capabilities [30]	Reservations	System integration capabilities [30]
42	Real-time information collection for collaborative management [5]	On-site information collection [30]	Incorporation	Real-time information collection for collaborative management [5]
43	Methods of Data acquisition [57]		Reservations	Methods of Data acquisition [57]
44	Automatic data processing [30]	Automatic data processing [30]	Reservations	Automatic data processing [30]
45	Interactivity of Hardware and software [41]		Reservations	Interactivity of Hardware and software [41]
46		Information management for Cloud deployment (cloud computing)[30]	Reservations	Information management for Cloud deployment (cloud computing)[30]

Table S2. Evaluation criteria for qualitative indicators

Secondary indicators	Initial level	Development level	Normative level	Continuous optimization level
C12	Without collaborative design	Collaborative design based on 2D drawings and challenging professional collaboration	3D co-design with multi-software interaction	BIM collaborative design based on informatization platforms
C13	Split design based on 2D	Inverse 3D disassembly design based on a library of Prefabricated components	3D split design guided by a library of prefabricated components	BIM forward design guided by a library of prefabricated coomponents
C14	Absence of 3D modeling or simply 3D image modeling	The quantity of information presented in the model aligns with that specified on the construction drawings	Precise component dimensions accompanied by additional information regarding the components' production, transportation, assembly and so forth.	The model carries comprehensive information, includes changes during construction, and corresponds to the actual construction content.
C15	Not involving	Inadequate data interactivity and issues of data loss and corruption	Improved data interactivity; imported data can be used after simple modifications	Excellent data interactivity; imported data are complete, which can be used directly
C16	The degree of standardization and modularization of prefabricated components and parts is particularly low	An average degree of standardization and modularization of prefabricated components and parts	A high degree of standardization and modularization of prefabricated components and parts	Remarkably high degree of standardization and modularization of prefabricated components and parts
C21	Pure component construction site transferred to factory	Manual assembly line production	Production by automated assembly lines with reduced reliance on human labor	Unmanned industrial manufacturing
C22	Planning for passive production, using the construction unit's purchased goods as a guide	While interaction with the designer regarding component information does occur, the majority of the products are still manufactured according to the builder's order.	Interaction with design and construction data, which allows the determination of production schedules	Data interconnection, automation plans
C23	Conventional logistics and transportation solutions	Monitoring of logistics using technologies such as the Internet of Things	Optimization of transport route selection using IoT, GIS and other technologies	Informatization of the whole process management of loading, unloading, transportation and stacking of components
C24	Unattainable	Traceability of	Traceability of	Traceability of dynamic component

	traceability possible	location information	Positioning and quality information	information combined with BIM technology
C32	Human monitoring	Less accurate monitoring due to deficiencies in monitoring and surveillance facilities such as sensors	Improved and more accurate monitoring based on advanced monitoring facilities including sensors	Monitoring based on the integration of information technology is exceptionally effective and highly accurate, which allows timely and early warning
C33	Conventional equipment is applied solely	A small quantity of smart equipment is applied.	A high quantity of smart equipment is applied.	A huge quantity of smart equipment is applied.
C41	Safety officer administration and management; conventional safety education.	Monitoring and surveillance records are archived; instructions regarding safety are displayed on the screen.	Real-time hazard alerts for monitoring and surveillance facilities	Monitoring and surveillance facilities as well as smart wearable devices are used for monitoring real-time personnel health status and hazard sources to issue timely warnings.
C42	Verification of team size per shift and summarization of site leaders	Project access through gates for real names of laborers	Attendance and payroll statistics based on the real name system of labor services	Monitoring and analysis of labor information using big data
C43	Little informatization supervision is performed on material types.	A moderate quantity of informatization supervision is performed on material types.	A fair quantity of informatization supervision is performed on material types.	A significant quantity of informatization supervision is performed on material types.
C44	Routine Manual inspection	Less accurate monitoring due to deficiencies in monitoring and surveillance facilities such as sensors	Improved and more accurate monitoring based on advanced monitoring facilities including sensors	Highly effective monitoring based on a variety of information technology, which enables timely early warning
C51	Spot-check supervision by the environmental protection department	Establishment of a construction schedule; frequent water spraying to reduce pollution, etc.	Implementation of real-time monitoring, intelligent watering, and intervention in construction time in the project	Real-time delivery of environmental protection information via a connection to the environmental protection system
C52	Unregulated	Human supervision of construction waste transportation vehicles' attention to sanitary conditions and punctuality while on the road	License plate recognition technology automatically collects and screens vehicle license plate information; radio frequency technology for waste classification	Realization of dynamic and visual monitoring of information regarding transportation, vehicle positioning and etc., based on technologies including GIS, GPS and Internet of Things
C61	Conventional cost management	Cost management using BIM technology	Trend analysis and early warning of cost indicators using visual analysis techniques	Collection and mining of cost data for macro-control of costs using big data technology
C62	Conventional offline procurement model	BIM technology for rapid quantity calculation and pricing for	Procurement models incorporating BIM technology and e-commerce	A cloud computing-based procurement model that incorporates BIM technology and ecommerce

C63	Conventional contract management model	procurement Contract informatization online archiving and consulting services	Contract information is archived and accessed based on the privilege.	Dynamic, collaborative and networked contract management based on the contract information management platform
C71	None	Less functionality, full process system not connected	More comprehensive functionality, encompassing the entire process Data transfer is fast enough to satisfy the requirements of decision-making	Comprehensive-functionality; integrated management of the entire process
C72	Based on manual work efficiency	Delay in data transmission		Immediate, real-time delivery
C73	Field data collection using human judgment	Less intelligent methods of information collection, heavily rely on human	More intelligent means of information collection, have limited reliance on human	Extensive implementation of intelligent methods to collect information, which eradicates the necessity for human involvement in the process
C74	Manual operation	Manual processing, computer-assisted processing	Computerized processing, manual assistance	Big data analytics processing, highly efficient data processing
C75	No software interaction involved	Poor interaction between hardware and software disrupts normal operation	Average interactivity between hardware and software, but basically functional	The hardware and software interact fairly well and are able to function properly
C76	None	Utilization of public cloud leads to low level of data security; certain functions become idle	By employing a hybrid cloud, services are independently managed based on their levels of significance; certain obstacles hinder data interaction.	Utilization of private cloud; customized service features; high level of data security

Survey concerning the significance of evaluation indicators for assessing informatization maturity in assembly building projects

Respected Sir or Madam:

Greetings! I am a master's student at Nanjing Forestry University engaged in the composition of a dissertation with the following title: "Evaluation of Information Technology Maturity of Assembly Building Projects Based on CMM-CME Methodology — — Take a project in China as an example". The purpose of this questionnaire is to investigate "the degree of significance of the evaluation indexes for assessing the informationization maturity in assembly building projects".

Following literature review and data analysis, this paper assesses the maturity of informatization in assembled building projects from seven first-level indicators and 28 second-level indicators, namely, design informatization, production and transportation informatization, construction and assembly informatization, man-material-machine management informatization, environment management informatization, business management informatization, and project collaboration management informatization. In order to optimize the evaluation indexes, please rate the significance of each evaluation index on the maturity of informationization in assembled building projects.

Your support and engagement will be critical to the achievement of this study; herein you are asked to kindly complete the questionnaire meticulously according to your expertise and background. Moreover, we sincerely hope that you will encourage your acquaintances and colleagues who have engaged in projects similar to the research content of this paper to contribute to this survey. Any information you provide will be treated as confidential and utilized exclusively for academic research purposes.

Your cooperation is greatly appreciated!

Best of luck in your profession and life!

Nanjing Forestry University
August 2022

Part I: Basic information regarding the individuals being surveyed and their organization

1. Your academic background:_____
A. High school and below B. Specialized C. Bachelor's degree D. Master's or higher degree
2. Your job title:
A. Junior B. Intermediate C. Senior D. Other
3. The type of your organization:_____
A. Departments of government B. Construction units C. Design units D. Construction units E. Supervision units F. Units of Component production G. Consulting units H. Scientific research units and academic institutions I. Others
4. The duration of your employment in the construction industry:_____
A. 1 year and below B. 2-4 years C. 5-8 years D. More than 8 years
5. The number of years you have been engaged in assembly building related business:_____
A. 1 year or less B. 2-4 years C. 5-8 years D. Over 8 years
6. Your level of knowledge about assembly building projects:_____
A. Extremely well known B. Comparatively well known C. Generally well known D. Not very well known E. Not at all well known
7. Your proficiency in understanding informatization construction for assembly building projects:_____
A. Extremely well-known B. Comparatively well-known C. Generally well-known D. Not particularly well-known E. Completely unknown
8. Your understanding upon smart construction:_____
A. Extremely well-known B. Comparatively well-known C. Generally well-known D. Not particularly well-known E. Completely unknown

Part II: This section focuses on evaluating the significance of the 28 secondary indicators. Please assess the importance of the maturity of information technology in assembly building projects, as suggested by the indicators, using your personal experience and the current status of information technology in building such projects as a guide. Please indicate your rating with a "√" in the corresponding table. (The evaluation process is based on a 5-point Likert scale, where 1 indicates "negligible", 2 indicates "unimportant", 3 indicates "generally important", 4 means "important", and 5 indicates "extremely important".)

Secondary indicators	Negligible (1)	Unimportant (2)	Generally important (3)	Important (4)	Extremely important (5)	Note
The degree of application of BIM design performance						Implement BIM technology for

						analysis of the site, the sunlight, the wind, the noise, program comparison, etc.
BIM collaborative design						Degree of collaborative design among architectural, structural, plumbing, electrical, and renovation disciplines
Split design of prefabricated components						Level of Informatization regarding prefabricated component splitting methods
BIM modeling accuracy						Level of details of building information modeling (LOD100, LOD200, LOD300, LOD400, LOD500)
BIM software data interactivity						Data interactivity between software used in the design process
Standardized design of components						Degree of generalization, standardization and serialization of component design
Informatization of production equipment						Prefabricated components production automation, intelligent degree, unmanned factory production
Component production scheduling informationization						Degree of informatization of production scheduling, degree of interactions among design, production and construction data
Informatization of the component transportation programme						Optimization of logistics solutions based on the Internet of Things
Informationization of component traceability						Degree of application of

						information technology in component identification, positioning and stacking planning
Construction assembly plan informatization						Degree of application of information technology such as 3D delivery, construction site dynamic layout simulation, construction plan optimization using 4D virtual construction, 4D progress simulation, etc.
Construction equipment informatization						The degree of informationized monitoring of grouting compactness, deep foundation pits, highly supported molds, and adjacent engineering works
Construction equipment informatization						The level of informatization of grouting, lifting and other equipment, the degree of application of intelligent equipment including s BIM CNC processing and automatic arrangement of reinforcement bars, measuring robots, etc.
Informatization of personnel security management						Using VR, AI and other virtual reality technologies to monitor the safety behavior of personnel, identify hazards and issue action alerts
Labor monitoring informatization						Degree of informatization of

						the real name system of labor (attendance, payroll, labor data management)
Material supervision informatization						BIM, IoT RF technology applications, stockpile planning
Informatization of machinery and equipment safety monitoring						The quantity of sensors, monitoring and other instruments, big data analysis, and hazard warning
Environmental monitoring informatization						Visualization of Dust, noise, water and other elements via remote supervision; intelligent linkage between the relevant departments
Informatization of construction waste regulation						Comprehensive monitoring of construction waste using technologies such as GIS and Internet of Things (IoT)
Informatization of an Engineering collaborative management platform						Integrity and intelligence of platform functions
Collaborative management information collection in real time						Timeliness of information collection
Informatization of data collection methods						Information collection methods, such as the application of BIM, RFID, NFC, drones, etc.
Data processing informatization						Capabilities to automatically generate, summarize and query data, on the amount of labor and materials consumed at various stages of construction
Interactivity of hardware and software						Matchability between hardware and software

Cloud deployment information management						An approach based on Cloud computing that improves information resource utilization and thus reduces the cost of it
Cost management informatization						A capability of cost management of engineering projects based on the cost management informationization and big data technology
Procurement management informatization						Procurement informatization using cloud computing technology and e-commerce models.
Contract management informatization						Information management of construction contracts, including electronic contracts.

Part III: Observations and recommendations