

Research Article

Innovative Research on Collaborative Design Mechanism of Cave Dwellings in Henan under Cloud Environment

Shukun Rong ¹, Xiaohua Liu,² and Chen Bai¹

¹Art Design College, Henan University of Urban Construction, Pingdingshan, Henan 467036, China

²School of Foreign Training, Henan University of Urban Construction, Pingdingshan, Henan 467036, China

Correspondence should be addressed to Shukun Rong; 30180404@hncj.edu.cn

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Collaborative design is an important link in building construction at present, while the communication and cooperation among disciplines need further regulation. In order to maintain the cost-effectiveness and design quality of building engineering in the competitive environment and obtain higher economic benefits, the design team must ensure the collaborative design quality of building engineering. Based on the analysis of collaboration theory and collaboration mechanism, a collaborative design platform for caves in Henan province is constructed under the current cloud environment. In addition, the requirements and non-functional requirements of the platform are analyzed, and the overall structure with each part is designed specifically, hoping to improve the quality of collaborative design effectively.

1. Introduction

For the building industry, the traditional design presents a linear pattern. After the independent design of each major is completed, the information r is relatively independent, which is not conducive to the integration of design data and information [1]. The collaborative design mode under the building cloud platform can enable all majors to design collaboratively in a parallel way and solve the problem of noncommunication data through the building cloud platform [2]. Furthermore, different forms of architectural design can be displayed on the same platform, and all designs are completed in three-dimensional state, without space imagination of two-dimensional drawings [3].

Henan province is located in the transition zone between the second and third steps in China, and its topography is very complex, with many types of geographical features such as mountains, hills, basins, and plains. Under the influence of specific natural environment, residents living in mountainous areas, hills, tablelands, and gullies have created cave dwellings with local characteristics. Cave villages contain the ecological wisdom of residents' site selection and construction. However, compared with ordinary villages in plain areas, the

economic development of Henan cave villages is generally backward, the economic industry of the villages can no longer meet the employment needs, and a large number of rural populations, especially the young and middle-aged people, are constantly flowing into cities. It directly leads to the aging and waste of cave villages. Therefore, it is necessary to carry out innovative research on collaborative design mechanism of Henan caves. In this paper, Henan cave dwellings are taken as the research object, and its design collaboration platform is built, hoping to realize the innovation of architectural design innovation mechanism.

2. Overview of Collaborative Design in Henan Cave Dwelling

2.1. Synergy Theory. German physicist Haken established the synergy theory and put forward that competition is the premise of synergy. The open system develops from stable state to unstable state, and the system spontaneously forms a new relatively stable state through internal synergy effect. In this process, with the change from disorder to order, from discrete to whole, it can generate new energy exceeding the total of each subsystem [4].

The understanding of “cooperation” can be divided into narrow sense and broad sense. The narrow sense only contains the meaning of cooperation. Broadly speaking, it includes the dual states of cooperation and competition, and the final result is a win-win situation. [5] The cooperation described in this paper is generalized cooperation. Participants in various industries and their behaviors form a social system, and participants are in a state of constant competition that can highlight the significance of cooperation. In the process of competition, participants absorb other people’s knowledge for their own use, or provide their own knowledge to others in the process of cooperation, so that they can be integrated in the process of giving and receiving. New energy can be generated, which exerts greater efficacy and producing a cooperative effect of $1 + 1 > 2$. Therefore, collaborative behavior is a spontaneous and indispensable link in the development of industry and society, a catalyst to promote knowledge and technology innovation, and of great significance to advance science and society [6, 7].

2.2. Collaborative Design of Henan Cave Dwelling

2.2.1. Design Basis of Henan Cave Dwelling. The parapet wall is set on the kiln face in Henan cave dwelling, that is, the top of the kiln, and the flower wall is formed by brick carving, and the overlapping neckline is similar to the courtyard wall. The face of the kiln is also decorated in the form of the hanging flower gate building on the door wall, and embossed patterns are made on the kiln face and wall. The face decoration of the kiln is relatively complex, and the whole kiln is decorated with brick carving pattern of hanging flower curtain. Referring to the modeling characteristics of the garden’s hanging flower gate building, bas-relief is generally made on the surrounding parts, with the top circle and the bottom square so as to conform to the cosmology of “unity of nature and human.” In addition, there are “upper bright windows” on the door of the cave dwelling, and the window lattice will be carved with simple patterns. Niches will be set on the east and west sides of the cave door to worship relevant gods, and corresponding carvings will be made around the niches, as shown in Figure 1.

2.2.2. Design Characteristics of Henan Cave Dwelling. Building multi-agent synergy mechanism is divided into internal coordination and external coordination. The internal synergy mechanism is based on the interior of the multi-agent coordination system. According to its own characteristics, by establishing a reasonable organizational structure, information transmission mode and benefit distribution standard, and so on, it gives full play to the maximum advantages of each subject so as to achieve common goals and strive for the maximization of overall benefits. The external synergy mechanism is to promote the cooperation of all subjects in the system through external conditions, such as policy, market, and environment [10]. The establishment of the synergy mechanism is conducive to the cooperation of all participants in the competition. Through mutual learning, integration, and innovation, the



FIGURE 1: Front eave wall of Henan cave dwelling.

core values of enterprises can be enhanced, and the risks brought by environmental changes can be resisted [11]. The scope of this paper is the multi-agent internal synergy mechanism, which can overcome the shortcomings in the process of building construction and show its advantages of development by jointly establishing the work flow and rules system.

The characteristic of Henan cave dwelling is that almost every component is decorated with carving and color, and the techniques used by different decoration carriers are also different. In the selection and use of patterns and patterns, according to the shape of decorative parts and material characteristics, the conformal processing and the application of art according to the material fully show the beauty and artistry of the material, as shown in Figure 2.

Although there are many types of decorative themes and patterns, there are also repeated patterns. The same kind of pattern is in different positions; the outline of the graph and the combination of the graph expression are not the same. From the point of view of the decorative parts of the pattern and the graphic expression of the pattern, the pattern will adopt the conformal processing techniques according to the morphological changes of the decorative parts so that the pattern is highly consistent with the body, which reflects a high degree of coordination both from the content and form expression.

3. Demand Analysis

3.1. Business Analysis. In order to carry out innovative design of Henan caves, A Design Institute is selected as the design company to carry out the construction of collaborative design platform.

A Design Institute employs nearly 200 people, including about 120 designers, more than 50 project managers, and project procurement and other management departments. The number of large and small projects carried out in a year exceeds 30, and the projects are generally managed by stages, such as establishment stage, feasibility study stage, project preliminary design stage, detailed design stage, construction management stage, and so on. The project is initiated by the management department, and the preliminary work of the project is carried out after being approved by the leaders of the company, including planning, engineering estimation, and other work, and the planned tasks are distributed to the



FIGURE 2: Characteristics of Henan cave dwellings.

design department to carry out the design. Then, the department of design will carry out the management according to the requirements, including the preparation, modification, audit, capital raising, and countersignature of the design documents, and finally submit the construction drawings for the project construction. In the process of construction, there will be design alteration and construction rework, and so on. After the final construction of the project is completed, the department of management prepares the completion data and organizes the acceptance of relevant parties of the project. If the acceptance fails, rectification is required, and the project will be delivered after the acceptance of the project is passed.

Co-design of cave dwellings project mainly includes general layout, architecture, structure, water supply and drainage, heating, ventilation, and electricity, and some unconfigured design majors usually choose outsourcing design. Professional design software includes AutoCAD, Revit, MicroStation, and other domestic CAD software. According to the requirements of the project owner, the project design includes both 2D drawing design and 3D model design. Like most architectural design company, Z Architectural Design Institute still focuses on 2D drawing design with supplement of 3D modeling. In order to cultivate the 3D modeling ability, a BIM team of 10 people was set up to carry out 3D forward design and explore the modeling mode of 3D model, the process of model verification, model demonstration and construction management, and so on.

The traditional project drawing proofreading is that after printing the drawings, the personnel are organized to hold a meeting for centralized audit, fill in the drawing audit sheet, feed back to the designer, and then print the drawings again for audit. After many times of printing and modification, the final version of the project construction drawings is finally formed until there is no review and modification opinion. The process of drawing proofreading is very time-consuming of paper and personnel [12]. When the design task is tight, the designers often work overtime to solve the project design schedule, and employees will complain about it. In addition, management includes project manager, construction management, project cost, safety administrator, and data management, and project resources, plans, and costs are managed through the existing project management system [13].

Generally, the project site is located in different places, and the information is communicated with the staff in the office of the design institute by telephone and e-mail, so it is difficult to record the process information through the project event document [14]. Design drawings are generally

transmitted through instant chat software and network disk, and the confidentiality of project information is uncontrolled [15]. If the updated drawings are not transmitted in time or the notes are inaccurate, it is easy to cause information asymmetry, which makes the design and construction inconsistent and requires rework.

Without the management of document system, the project documents are scattered on the computers of project personnel. There is no unified standard for the line shape, line color, drawing frame, and font of project drawings, and the drawing naming is not strictly in accordance with the specification requirements. When the project is completed and delivered, the final archived drawings and forms of the project often have errors in version and content, part of the project management information is even missing, and some forms specified in ISO quality system are often filled in after the completion of the project, which has laid hidden dangers for the design quality management and also brought certain difficulties to the project settlement and subsequent maintenance and reconstruction of the project. The existing OA system has solved the audit and archiving of office documents, and the project management system solves the tracking management of project resources, plans, and costs but cannot meet the requirements of design management.

3.2. Overview of Platform Requirements. The co-design platform of cave dwellings needs to support the existing professional design software, can flexibly customize the catalogue structure of engineering projects, store and manage various documents and materials of projects, and support online proofreading and annotation of 2D design drawings and 3D models. The platform is deployed in the local area network of the company and can be published on the Internet for access by other participants of the project. The platform also needs to have API interface to realize data interaction with other systems.

3.2.1. Synchronize the Architecture. Reduce the repeated entry of project data, automatically import the project management architecture in the project management system into the design management platform, and automatically give information such as attributes so as to realize data flow between information system platforms through middleware.

3.2.2. Document Management. The first consideration of the design platform is to serve the project personnel, who design the project through professional design software and compile the project management documents with office software. The design software includes AutoDesk software and Bentley software; the office software includes Microsoft Office and Adobe Reader [16]. There are many kinds of applications where many formats of files have been produced, and these files are scattered in the minds of project personnel, which requires a compatible platform. The files of the whole project are stored in the project directory according to certain rules, which can be accessed by project personnel with project authority, thus improving the

security, accuracy, and timeliness of project information, as well as the communication efficiency of project participants.

For files about co-design of cave dwellings on the platform, fuzzy search can be performed by file name, or advanced search can be performed by file attribute [17] which is convenient for users to find the required files quickly when they are unfamiliar with the project folder structure.

3.2.3. Standardize Design Standards. Project design documents are designed by the professional designers who participate in the project according to the distribution of project work packages, so it is necessary to formulate a unified project rule to constrain the project personnel to carry out standardized work [18]. The design platform needs to set template files and document coding rules and unify the file design and naming requirements of project personnel so as to realize the standardization of design documents.

3.2.4. Collaborative Design. The co-design management platform of cave dwellings needs to integrate design software, office software, and so on so as to read files on the design platform for editing and modification or read files for editing and modification in software [19]. Reference design is needed between upstream and downstream disciplines. Once the file path is changed in Windows, its reference will be invalid. The management platform should support the reference relationships between design documents and maintain relationships of these dynamic reference [20]. Design files will generate multiple versions of files due to design problems or external condition table updating. In file reference design, it is necessary to support the file to automatically update the reference content with the version, that is, the latest version of the reference file.

3.2.5. Process Management. The co-design platform of cave dwellings should have the function of document flow management, display the current process status of documents, support serial processes and parallel processes, and realize the associated setting of workflow and role permissions [21]. When the status of the document changes in the process, it needs to get the function of reminding and guiding so that the annotation information in the process of document circulation can be saved and can be viewed at any time.

3.2.6. Real-Time Update of Data. After the project personnel upload or update the document, it can be read in real time by other personnel with access rights. The server should support distributed storage management, ensure that the project team members in different places can access the latest data in real time, eliminate geographical restrictions, and provide the functions of local cache and incremental transmission in different places. At the same time, it is also necessary to support flexible timing synchronization of project documents in different places.

3.2.7. Project Data Security. The account of the company's design management platform uses Windows domain account to realize single sign-on. The external cooperators of the company are assigned to log in with the new platform account [22]. There are many project participants, and under the premise of sharing project documents, it is also necessary to ensure the safe access and storage of information content. The design of the management platform needs to satisfy the login of account password and assign appropriate permissions according to the role of the project so as to prevent users from viewing some unauthorized project files, which can ensure data integrity from being used by unauthorized users, ensure that unauthorized users cannot make unauthorized modifications to data, and ensure that users with permissions can access data and resources timely. In addition to authentication, it is also necessary to encrypt the transmission of project files to ensure the safe transmission of data on LAN and Internet.

3.2.8. Platform Access. The co-design management platform of cave dwellings needs to provide data management and storage on the server side, which provides the access to the server through the client side. In addition to carrying out collaborative work, it is also necessary to meet the needs of collaborative work on the Internet and with proxy server to publish to the Internet to ensure data security [23]. For multiple workplaces, multisite expansion deployment can be realized, where LAN and Internet users all obtain access of desktop client and browser.

3.3. Nonfunctional Requirements of the Platform. On the premise of meeting the functional requirements of the information system, the co-design management platform of Henan cave dwellings studied in this paper also needs to meet the nonfunctional requirements, such as rapid response and stable operation of the platform. Nonfunctional requirements are mainly reflected in the following aspects:

- (1) *Response Time.* When platform users edit or view folders and documents, the reading of documents should be presented to users within the acceptable range of users, and the response time should be less than 1 s.
- (2) *Number of Concurrent Users.* When a large number of users access the platform at the same time, the platform needs to have good concurrent processing ability to meet the processing requests of a fixed number of users [24]. This research requires that the platform can carry at least 200 users.
- (3) *Ease of Use.* The interface is simple and operation is simple, while the structure is clear. The client can use it after simple training.
- (4) *Maintainability.* The co-design management platform of cave dwellings has an independent maintenance interface, which can set and maintain the platform to meet the configuration requirements of client users [25].

- (5) *Disaster Tolerance*. The platform needs to have a certain disaster tolerance capability, and it needs to have an automatic recovery function when encountering unexpected situations, such as fire and earthquake.
- (6) *Extensibility*. The platform needs modular architecture, and the modules have strong independence [26]. It can select functional modules according to users' requirements, otherwise expand the use function by adding modules, and it will not affect use with the expansion of requirements which integrates with other information systems to realize data interaction.

4. Design of the Platform

4.1. Overall Structure. The co-design platform database of cave dwellings is used to store the platform directory, users, permissions, attributes, processes, and other information, and the file server is used to store the files. In addition, the platform is applied to project personnel, and the interaction between the client and the server is connected to realize the functions of user login, permission control, file reading, system maintenance, and so on. The application layer is responsible for content display and provide clients for users to send and receive commands. The application layer uses the integration server and file server to interact with the database and file storage devices [27]. When the application layer sends instructions, the integration server and the file server are responsible for transmitting the instructions to the database and the file storage device, respectively. When that database and file storage device send the original data, the integration server and file server interpret it and send it to the application layer [28]. The logic architecture diagram of the platform is divided into three layers: application layer, logic layer, and data layer, as shown in Figure 3.

Considering that the project personnel are scattered in different office locations, the platform can be accessed on both LAN and Internet, and the efficiency of access should be considered. The form of coexistence of platform C/S and B/S mode is selected, which effectively solves the need of designers to carry out the co-design of cave dwellings through platform client in the company. At the same time, it also solves the need for the personnel of different project departments to access shared files through browsers.

4.2. Specific Design

4.2.1. Functional Design. According to the demand analysis, the functions of co-design platform of cave dwellings are divided into four blocks: environment configuration, co-design of cave dwellings, drawing proofreading, and data storage of cave dwelling patterns. The design diagram of the main function tree of the design platform is shown in Figure 4.

In the environment configuration, multiple data sources can be created, and each data source can include multiple projects [29]. Administrators log in to a data

source, synchronize Windows domain control users, create new logical users for the use of project partners, and set up project roles for all users. Figure 5 shows the relationship among data sources, projects, and accounts on the platform.

A Design Institute already has a project management system, but the API interface of this system is limited, so it can only provide data values and cannot import data. Therefore, the project management system data outputs them to the design management platform in one direction. In addition, this platform needs to realize the synchronization of project architecture and project attribute data from the existing project management system through secondary development so as to achieve data synchronization between the platform and the project management system [30]. Because the project management system does not open the corresponding API, this development only realizes one-way data transfer from the project management system to the design management platform and realizes one-way data transfer through intermediate files.

In collaborative design of cave dwelling patterns, users can integrate, read the documents on the platform, and edit and update the contents of the documents according to the design software of this major. When the documents encounter an upgraded version, they can update the version of the documents through version management and keep the latest version as an active editable version. At the same time, in the process of design, collaboration among specialties can be carried out by referring to the design, and the content of platform documents about cave dwelling patterns can be shared in real time to improve the collaboration efficiency among specialties [31]. Users can also communicate project information in time through message service on the platform, customize document attributes according to the needs of the project, and search documents through basic attributes of documents. After the final assembly model is generated, it can be converted into a lightweight file called i-Model for collision check and calibration.

During the process, it is necessary to review the drawings and documents of cave dwelling patterns, which is a mandatory requirement in design management. Usually, it is necessary to carry out intradiscipline audit, interdiscipline fund raising, and interdiscipline countersignature and change the process status by setting judgment conditions. If there is any modification, it will be returned and submitted for review again until it is approved. The whole audit process is carried out on the platform, and the review is recorded to facilitate the subsequent ISO review.

In the safe storage of data, it is required to store data centrally and view the operation records of the platform to meet the needs of various access modes in different places, and the influence on the bandwidth in the process of document transmission ought to be considered. Through the distributed storage deployment architecture in different places and the incremental document transmission technology, the requirements of the platform data transmission on the network bandwidth can be reduced, which improves the efficiency of collaboration in different places.

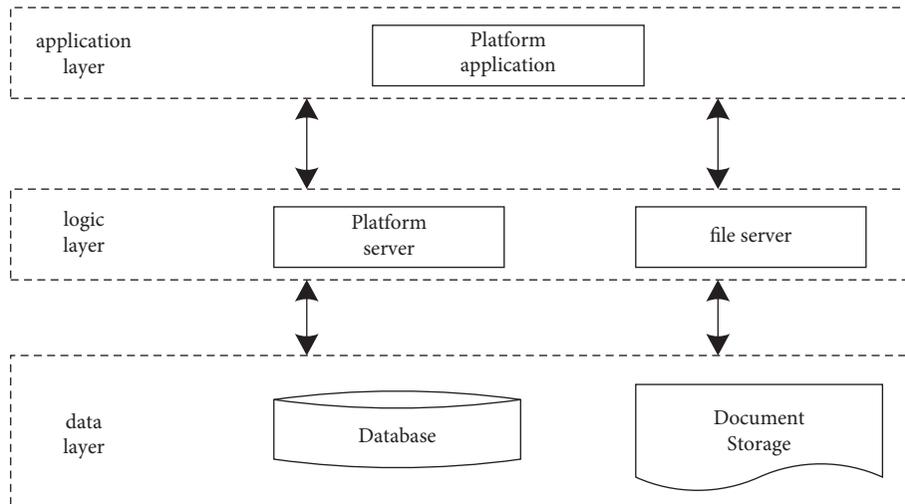


FIGURE 3: Logical architecture diagram of architectural design management platform.

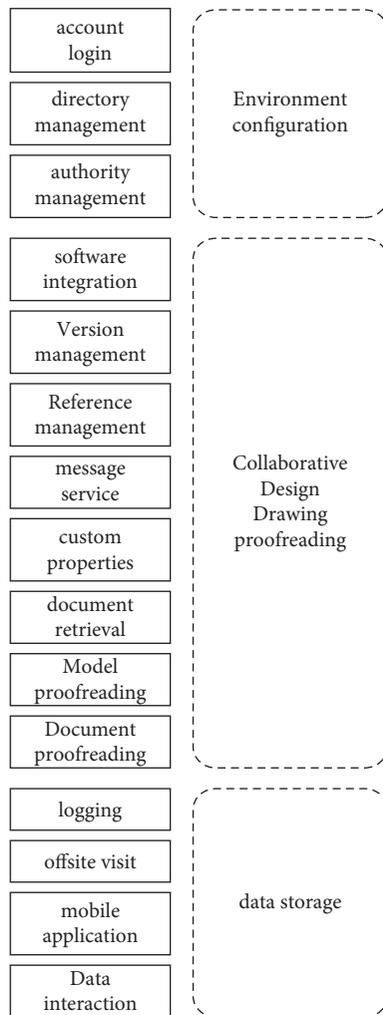


FIGURE 4: Function tree diagram.

4.2.2. Mechanism of Data Storage. Centralized management of cave dwelling patterns documents distributed on project personnel's computers ensures the unified control of project

contents, while real-time synchronization of data can make project participants get the latest information, which improves the efficiency of collaborative work i .

With the platform under database + file storage mode, the project files are stored in the server, while the relationships between files and attribute i are stored in the database [32]. Multiple projects under one data source can be managed, and multiple projects under separate data sources can be achieved by establishing multiple data sources.

The designer's client adopts the standard client/server (C/S) access mode, which meets the high-performance collaborative work requirements of designers. For the external participants of the project, project site personnel, or business travelers, the browser/server (B/S) access mode is adopted to meet the needs of project document sharing without installing any application programs. At the same time, it provides access methods for mobile devices, including mobile phones and tablet computers, and provides engineers with the function of accessing project-wise data anytime, anywhere.

(1) *Audit Management.* All users' operations on the document, including username, operation action, operation time, and user's additional annotation, will be automatically recorded by the platform, which is convenient for users to review and track later.

(2) *Data Storage.* The platform data storage adopts the scheme of combining relational database with file system in Windows, which unifies the storage access mode and can support the storage of multiproject data in multidata sources.

File storage about cave dwelling patterns adopts NTFS (New Technology File System), which is the default of Windows server. It is a disk format specially designed for network, file encryption, and other security features, which supports long file names, data protection, and data recovery. Considering the economic cost of storage, the file storage server of the platform is not set up separately but is deployed together with the integrated server.

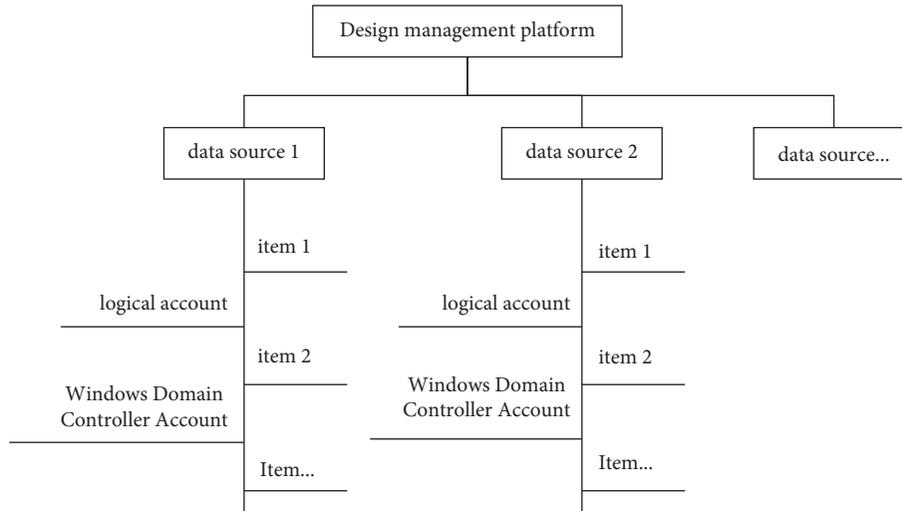


FIGURE 5: Diagram of data source design.

Database storage supports SQL Server and Oracle to store structured data. By creating an association between project-wise and database through ODBC and employing it to create a new project-wise data source, it provides access for clients. The database stores the account information, document attributes, folder attributes, workflow, application relationship, platform settings, and other contents of the platform.

(3) *Remote Cache Technology.* In order to improve the speed of users visiting the server in different places, a cache server can be deployed in different places to store local copies of documents. Through the association of storage areas, there are many storage areas in the data source, each storage area is located on a different computer, and real-time data synchronization is realized through the network.

Data synchronization between remote servers and local servers will take up much network resources. In order to reduce the network load, the real-time synchronization of a large amount of data in different places is realized by using the technology of Delta File Transfer, (DFT). When a user reads a document, the platform will query the cache server to determine whether the latest copy of the document is on the cache server. If the cache copy does not exist, then the cached copy will be transmitted from the server to the client; at the same time, if the cached copy is out of date, only the modified part of the document will be transferred to optimize the document transfer. Similarly, when a user uploads an updated document, only the modified part of the document is transmitted, which greatly reduces the number of network transmissions and improves the efficiency of network access.

4.2.3. *Database Design.* Project-wise supports SQL Server and Oracle database, and SQL Server has been used as the database of company information system in A Design Institute, so the database of this platform still select SQL Server.

According to the co-design platform of cave dwellings business analysis of the defined object, its responsibilities can be fully described from the defined data items where an object has only one responsibility. Minimizing the data redundancy of the table ensures the accuracy of the data and effectively improves the performance. In this paper, the database is divided according to the platform components, and the tables of different components are related by the primary keys of the related tables to ensure the independence of tables corresponding to components and facilitate the reconstruction of table structure in secondary development.

The platform database mainly includes four data tables: the main function table of the platform, including users, project folder creation, document storage area, and documents. Set the relational database in the database, as shown in Figure 6.

Because of the huge database design of the co-design platform of cave dwellings, this chapter only lists some contents, such as creating users, creating projects, creating documents, setting processes, accessing records, message boxes, and so on. In addition, the platform creates new users, stores user information, and gives users initial permissions. While in the process of creating new projects and documents, the system records its corresponding attribute information, sets the storage path, and can add project attributes and set project personnel permissions. Afterwards, the users can set the process for the document and carry out the process flow. In the process of document review, the system records the actions and information of the operator and triggers a message box in association with the corresponding documents and notices to inform the corresponding agents. All operations in the platform are recorded and can be viewed at any time.

Finally, add new database tables used in secondary development, such as user-defined design attribute module table, which mainly defines project folders and their attributes; the user-defined module of drawing review process mainly defines status, process, process status approver,

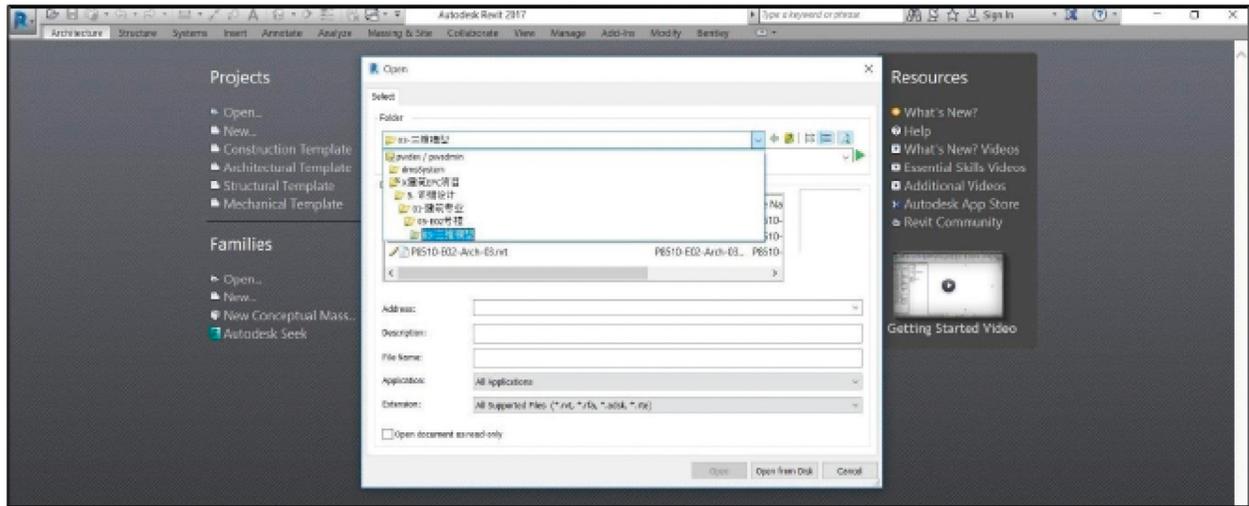


FIGURE 8: Integration page.

TABLE 1: Function tests.

Test function	Test methods and test steps	Test Results
User login	The user enters the user name and password to test the system login function	Pass through
Configuration management	Create a new data source, set the network connection method, set the system permissions, configure the process, configure the environment properties, configure the message box, configure the application	Pass through
User settings	Create new users and synchronize domain control users. User account creation, import, and synchronization are all normal	Pass through
New project	Import project schemas, plans, and properties. Import the MPP document exported from the project management system on the platform.	Pass through
Folder management	Operates on the folder menu. New, open, copy, cut, paste, rename, delete operations are normal	Pass through
Document management	Operates on the document menu. New document, new version, open, copy, cut, paste, rename, start process, delete are normal	Pass through
Application integration	After installing the integrated plug-in, the corresponding documents on the project-wise platform can be opened in MicroStation, AutoCAD, and Revit software and the reference documents can be read. Double-clicking a document on the platform can launch the corresponding application to perform operations such as checking out, editing, and checking in. You can also select documents on the platform to perform operations such as checking out, editing, and checking in in the application. It is verified that the integration of platform and software is bidirectional	Pass through
Reference design	In the design software, through the “file link” method, select the file on the platform to carry out the reference design, and the referenced document is only displayed and cannot be modified	Pass through
Publish <i>i</i> -Model files	Publish final assembly model RVT files and DGN files as <i>i</i> -Model files Open a lightweight read-only model; you can browse the model and view build property information, but cannot edit it Select process, select reviewer, transfer status, and submit review comments	Pass through
Drawing review	Every operation and review comments of process submission and rollback are saved for authorized users to view the review process records at any time The final assembly model performs model collision, annotation, and so on	Pass through
Model proofreading	Select the relevant professional components that need to be checked for collision, and the software will automatically start the collision check and list the collision points in the model. Click on a collision point to redline and generate an independent annotation file without affecting the content of the source file	Pass through

process review log record, status and process association, document and process association, and message box and process association.

5. Implementation and Test of Platform

5.1. Implementation of the Platform. Users can normally access the project-wise platform in local area network and other places and carry out collaborative work by logging into the client of the project-wise platform. Every user logs in through his/her personal account. And no matter what kind of network he/she connects to the project-wise platform, the content of the user interface is consistent. It can be selected to insert linked documents on the platform to carry out collaborative design, as shown in Figure 7.

When the plug-in is installed, the “Bentley” column is displayed in the menu of Revit software. Click the “Open” button, and a login dialog box of the design management platform will pop up. After logging in, users can select the document of the design management platform to open and carry out model design, as shown in Figure 8.

5.2. Testing of the Platform. Through detailed tests of various system functions of the system, the test results are all passed, as shown in Table 1.

6. Concluding Remarks

In recent years, with the acceleration of urbanization, the domestic construction industry has experienced a period of rapid growth. The huge inefficiency and waste in the construction industry make people consider how to reform the production mode and organization mode of construction projects. With the development of cloud environment, the concept of collaborative design came into being. By applying to the co-design of cave dwellings, it is able to effectively deal with various data in the design stage and strengthen the communication between designers. In this paper, the collaborative design methods under the building cloud platform are combed in detail, and the platform is designed and implemented. Finally, the results of tests are excellent.

Data Availability

The dataset can be accessed upon request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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