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# Practical Application of BIM Technology
## BIM技术的实际应用

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Using Shanghai Tower as an example, this chapter introduces the effective applications of BIM technology in project design and construction along with the positive results achieved. The chapter also summarizes some problems encountered during the process of implementing BIM. Along with the growth of the Shanghai Tower, 4 years of BIM technology applied to the project played has an important role in different phases.

本文以上海中心项目为例，介绍了通过BIM技术在项目设计、施工阶段的有效应用，取得了较好的效果。同时整理和归纳了在进行BIM实施的过程中遇到的一些问题。伴随着这幢大楼的成长，BIM技术在项目中的应用也度过了4个年头，并在不同阶段发挥了重要的作用。

In the preliminary planning stage, the team set up the "lean management mode based on BIM technology dominated by the owner unit, with the fellowship of the participation unit," according to the characteristics of the project. In order to complete the information and process management based on this mode, and considering that BIM data is vast and various, the project needed a unified platform. After multiple screenings, Autodesk Vault Professional was formally chosen for the project.

Autodesk Vault Professional is a data management platform based on a variety of technologies such as AutoCAD and Revit. On this platform, various project participants may browse online data, and complete various tasks with that data, such as download, modify, upload, etc. Meanwhile, this platform is highly compatible with other Autodesk software, which plays an important role in comprehensive data management. With its data tracking function, Vault can also control and observe the source and flow of all the data in this platform. It can also synchronize and network the data, which is more conducive for the BIM model update on site.

The platform has been thoroughly applied in the Shanghai Tower project. In addition, on the basis of the existing platform, we did secondary developments in view of the problems accrued in the process. This optimized the management and processes, and helped to improve BIM implementation in the project.

With responsible mechanisms and platforms in place, the whole project needed unification with BIM implementation standards for specific work instructions and specifications of each participant. Therefore, according to the BIM applications in Shanghai Tower, the owner set up the project implementation standards with stakeholder (Figure 5.4 and 5.5). This included the specific responsibilities for each participant, architectural requirements of the application software, file exchange and release requirements, model creation, maintenance and delivery requirements, and the details of each discipline term. As the project progresses, the standards will continue to be perfected. All project participants also hope to sum up the main points of the BIM implementation in the process of project, thereby helping to serve future projects.

在前期策划阶段，针对项目特点建立了"以建设单位为主导，参建单位共同参与的基于BIM技术的精益化管理模式"。为了完成基于该模式的信息和流程的管理，并且考虑到BIM资料的庞大繁多，项目需要规划及开设一个统一的工作平台，在经过多种筛选之后，Autodesk Vault Professional被正式应用在该项目中。

Autodesk Vault Professional是基于AutoCad、Autodesk Revit系列等多种技术所开发的数据平台。在平台上，项目各参与方可以做到线上数据浏览、下载、修改、上传等各项工作。并且与AutoCad、Revit系列软件高度契合，起到综合性数据管理功能。利用其良好的数据跟踪功能，还可以控制及观察平台内资料数据流动来源去向、数据网络同步，这样则更有利于BIM现场模型的更新。

该平台已经在上海中心大厦项目中进行了深入的应用。此外，在现有平台的基础上，建设方针对过程中出现的问题又做了二次开发，来优化管理和流程，以更好地帮助项目的实施。

有了责任机制和平台后，整个项目还需要统一的BIM实施标准 来对各参与方的具体工作进行指导和规范，针对上海中心的BIM应用，建设方同各参与方一同制定了相关

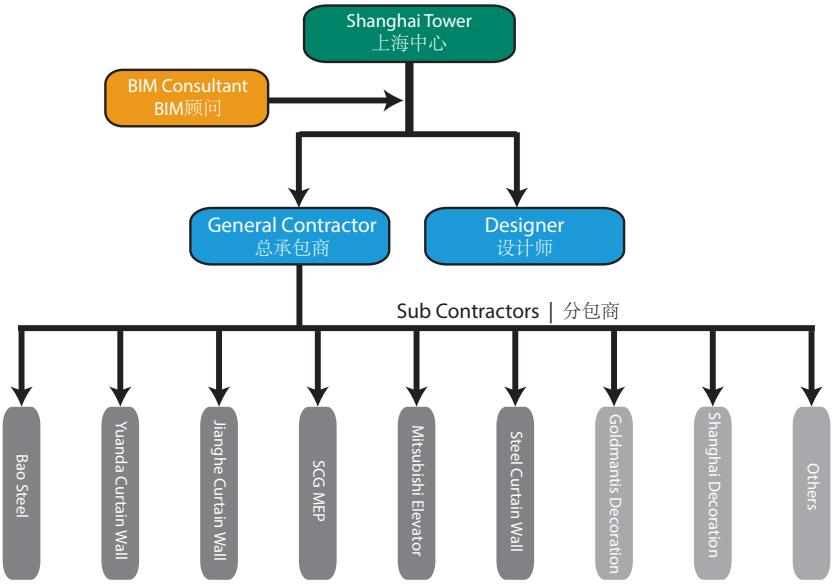


**Figure 5.3. Working organization framework of BIM (Source: Shanghai Tower Construction & Development Co., Ltd)**
图 5.3. BIM工作组织架构 (来源: 上海中心大厦建设发展有限公司)

All of the above efforts aim to make BIM the unified engineering language of the project and achieve the maximum use of project information.

At the same time, each participation unit established their BIM team under the request of tendering documentation, and appointed a specialist for BIM communication and coordination. The composition of the whole BIM work team in Shanghai Tower is shown in Figure 5.3.

In the process of design and construction, great changes in content of the BIM technology framework have also taken place. The number of software programs used gradually increased, from the most basic modeling software, Revit, subdivided into Tekla software to make steel structure. Inventor software assisted with factory processing. Solidworks software made the window-cleaning machine and Rhino software made the free form curved surface based on the professional characteristics. The scope of application is expanding increasingly as well. For instance, a model checking system has been formulated and we are developing our BIM engineering management system independently for the quantification of project quality, safety, and progress.

的项目实施标准 (见图5.4, 5.5)，其中详细规定了各参与方的具体工作职责，应用软件架构要求，文件交换和发布要求，模型创建、维护和交付要求以及各专业的细化条款等等。随着项目的进行，这套标准还将被继续完善，项目各方也希望通过这套标准总结出项目过程中BIM实施的要点，从而为以后的项目进行服务。

所有这些工作的目的就是要将BIM作为项目统一的工程语言，并借此达到项目信息的最大化使用。

与此同时，各参与单位也在招标内容的要求下，分别组建了其BIM工作团队，并指派专人负责BIM工作的沟通及协调。整个上海中心项目BIM工作团队的构成如图5.3所示。

在设计及建造过程中，BIM技术框架的内容也发生了很大的变化，使用的软件数量逐渐增多，由原先最基础的建模软件Revit扩展到根据专业特点细分成: Tekla做钢结构，Inventor配合工厂加工，Solidworks做擦窗机，Rhino做曲面异形等。应用的范围也日益扩大: 制定了模型审核制度，并尝试自主研发了BIM工程管理系统来对项目的质量、安全、进度进行信息化处理。

随着BIM技术应用的范围不断扩大，应用的深度不断加深，项目各阶段、各专业都取得了明显的效果。在外幕墙专业方面，实现了基于BIM的设计、加工、现场联动方式，绘制加工图效率提升200%，加工图数据转化效率提升50%，复杂构件测量效率提高10%; 在机电专业方面，利用BIM技术减少了60%现场制工作量，减少了90%的焊接、胶粘等危险与有毒有害作业，实现了70%管道制作预制率; 而在室内装饰方面，从模块化、工厂化的角度出发，结合BIM技术特点，大幅提高了室内装饰的工作质量与工作效率。

除此之外，我们还利用BIM模型在以下方面做了研究和实践，并实现了一定的价值 (见图5.6)。

- 辅助统计工程量
- 探讨短期及中期施工方案。
- 利用三维激光扫描等仪器提高现场施工的准确性。

从经济成本的角度来看，在大中型工程项目中，信息沟通问题导致的工程变更和错误费用约占工程总成本的3至5%。此类费用可以通过BIM信息化手段来避免。结合碰撞检测统

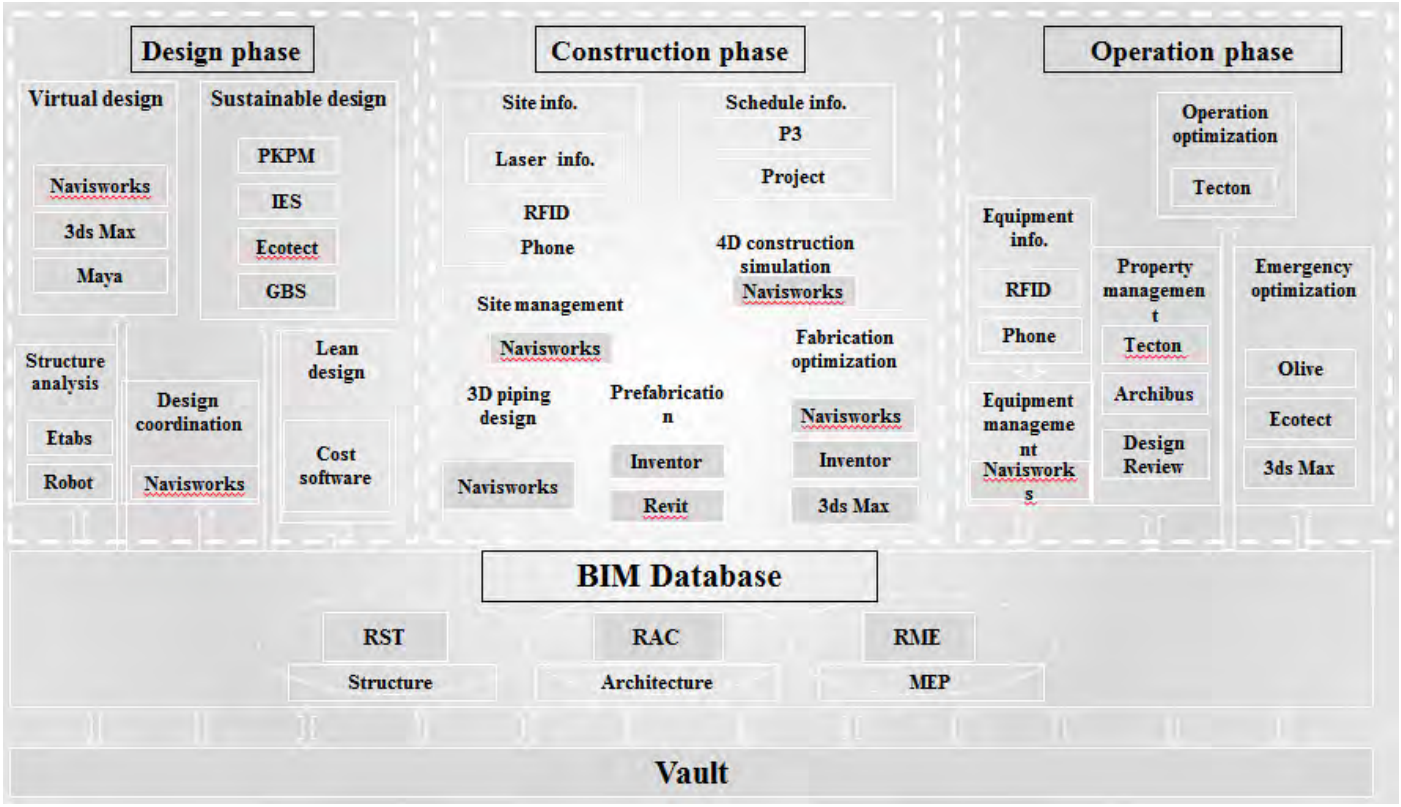


Figure 5.4. BIM technical framework (2010 version) (Source: Shanghai Tower Construction & Development Co., Ltd)
图 5.4. BIM技术框架 (2010版) (来源: 上海中心大厦建设发展有限公司)

With the application scope of BIM technology expanding and the application depth deepening, different stages and disciplines of the project have acquired obvious effects. This occurs in the external curtain wall discipline, design, processing, and site linkage mode based on BIM. Efficiency of the drawing and processing map has increased by 200% and the conversion efficiency of processing map data has increased by 50%. Furthermore, the measurement efficiency of complex components has increased by 10%. In MEP disciplines, using BIM technology could lead to a 60% reduction of on-site workload with a 90% reduction on welding. This reduces the use of adhesives and dangerous, poisonous, and harmful activities. Also, the application scope of BIM is achieving a 70% prefabrication rate of pipeline making. In terms of interior decoration, from the perspective of modularization and industrialization, work quality and the efficiency of interior decoration have greatly improved (see Figure 5.6).

Besides the actions above, we also conducted research and used BIM models in the following areas, and achieved a certain value.

- Quantity take-off assist
- Investigation of the short and medium construction schemes
- The use of 3-dimensional laser scanning equipment to improve the accuracy of on-site construction

Economically, engineering changes and error costs caused by information communication problems account for 3% to 5% of the total project cost in large and medium-sized construction projects. Such expenses can be avoided by means of BIM calculations. Estimation based on the clash quantities decreased by over 100,000 from clash detection statistics when BIM information technology is used. If we calculate the unit price of individual clash point on the basis of 1,000 RMB, more than 100 million RMB in total will be saved in the project.

However, in the process of BIM technology's implementation in the project, there are still some inevitable problems, and these problems need to be considered and solved now and in the next few years.

Formats of model data are numerous and compatibility of the managing software necessitates further improvement. The BIM technology applied to the Shanghai Tower project has adopted more than 10 kinds of software; each software having its own data format. Therefore there are

计的碰撞数量估算，在采用BIM信息化技术手段后，提前发现并解决的碰撞点总数超过10万个, 按单个碰撞点平均单价1000元左右计,保守估计本工程节约费用至少超过1亿元。

然而，BIM技术在项目实施的过程中依然存在一些不可规避的问题，而这些问题是现在以及今后几年内需要重点予以考虑并解决的。

模型数据格式众多，软件兼容性有待进一步提高。上海中心大厦项目目前在BIM技术的应用上已经采用了超过10款软件，而每一款软件都有自己的数据格式。因此在软件之间进行无损的数据互导，以及模型整合上存在一定的难度。虽然目前国际上在推广通用的数据格式IFC，各大软件商也皆开发了相应的数据接口，但一方面IFC格式依然在完善过程中，另一方面各软件商针对IFC格式接口的开发力度各不相同，导致在进行IFC格式转换中会出现信息丢失，甚至构件缺失的情况。而在采用Navisworks软件进行模型整合时，虽然其能够读取超过20种不同格式的软件数据，但依然存在部分信息丢失的情况。

模型文件容量大，实际浏览操作不够顺畅。在大型项目中，尤其是造型奇异、管线复杂的项目上采用BIM技术的效果非常明显。通过BIM技术的有效运用可以显著减少设计错误，提高设计质量，缩短施工工期，节约项目造价。而随着项目的规模越

certain difficulties in achieving lossless data transformation between the software and model integration. Although the universal data format IFC has been promoted internationally, each big software vendor also develops their own data interface. On one hand, IFC format is still in the process of perfection, on the other hand, software vendors have differing development strength with the IFC format interface, resulting in information loss and even component loss which appears in IFC format conversion. And when we used Navisworks software for model integration, data loss accrued as well, even though it can read more than 20 kinds of different software formats.

The model file is large in size, creating irregular browsing in actual operation. In large projects, the effect of using BIM technology is obvious, especially in the projects with free form shapes and complicated pipelines. Effective use of BIM technology can significantly reduce design errors, improve design quality, shorten the construction period, and reduce the building costs of projects. As the scale of the project gets bigger and bigger, depth and precision of the model get higher and higher. In conjunction, the size of the model file also becomes larger and larger. The most obvious consequence is the loading speed of the model file becoming slower; its operability becomes increasingly worse. So, reasonable regional division for the project model file is needed.

来越大，模型的深度和精细度越来越高，模型文件的容量也变得越来越大。最明显的特点就是模型文件打开的速度越来越慢，可操作性变得越来越差。因此，需要对项目模型文件做合理的区域划分。

模型重复使用的效率降低。此问题更多体现在由设计向施工过渡的阶段。目前大部分的情况是BIM团队人员依据设计团队的图纸来创建BIM模型，这就会产生模型与图纸有不一致的可能性；设计阶段的模型到了施工阶段时，模型的创建方式有所不同，建模深度与范围亦不足，需要由施工单位对模型做进一步深化，以满足施工阶段的应用。当这些问题严重的时候，就会发生施工单位自行依照设计图纸重新创建满足施工应用需求的BIM模型，而设计模型被重复使用的效率就会降低，项目有效信息重复

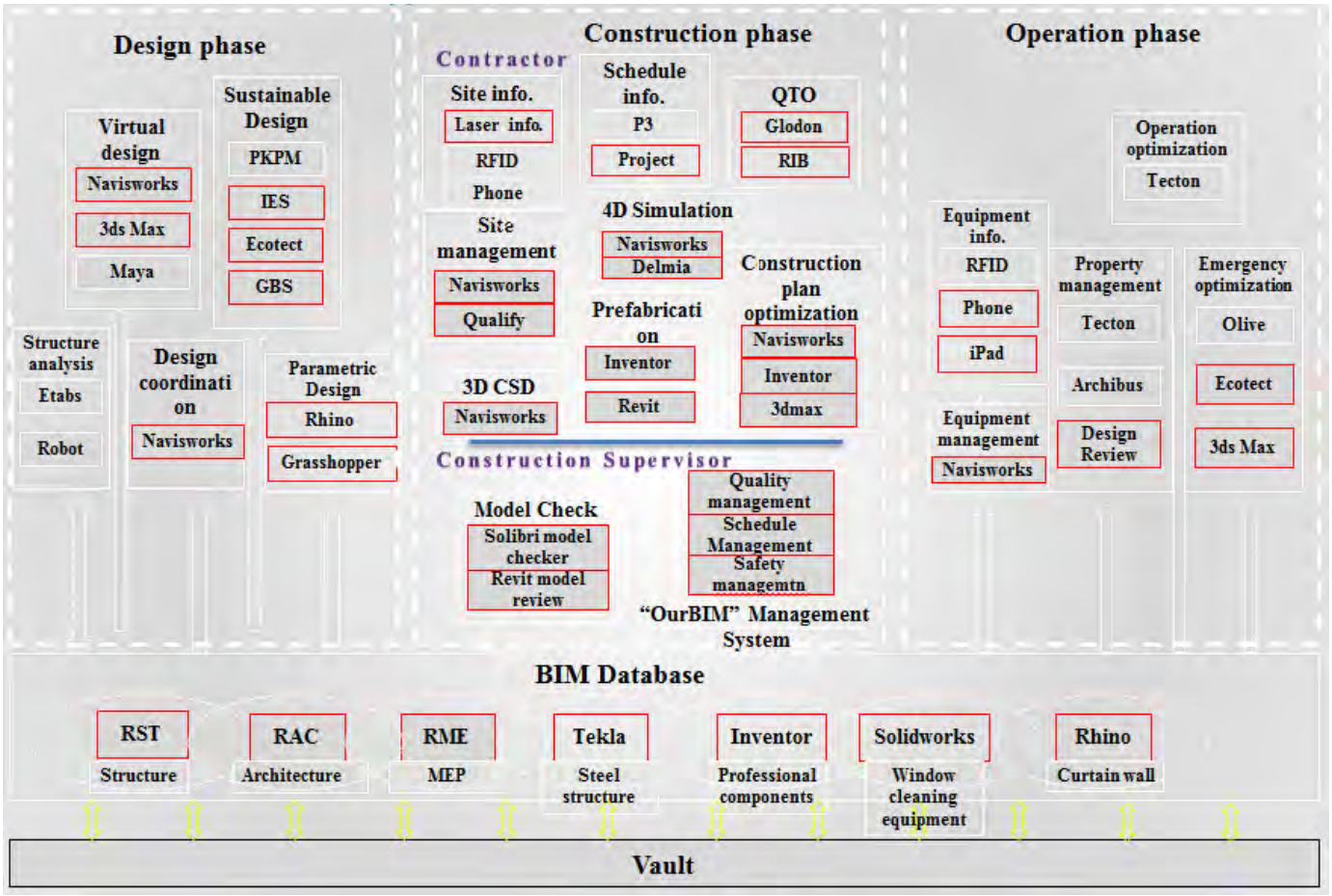


Figure 5.5. BIM technical framework (2013 version) (Source: Shanghai Tower Construction & Development Co., Ltd)
图5.5. BIM技术框架 (2013版) (来源: 上海中心大厦建设发展有限公司)


**Figure 5.6. BIM modelling used for interior finishes (Source: Shanghai Tower Construction & Development Co., Ltd)**
图 5.6. 室内装修中BIM模型的应用 (来源: 上海中心大厦建设发展有限公司)

Decreased efficiency of model reuse is a problem more embodied in the transition from the design to construction phases. Generally, the current situation is that the BIM team members create BIM models according to design team's drawings causing inconsistencies between models and drawings. When a model from the design phase moves to the construction stage, the method of model creation is different and lacks the necessary depth and range of modeling. Contractors need further elaboration, in order to utilize the application through the construction phase. When these problems become worse, contractors will recreate the BIM model in order to meet the demand of construction application in accordance with the design drawing, and the re-use efficiency of the design model will be reduced. Re-use hinders information contained within the design. Therefore in the early stage of the project, modeling rules need to be established. For instance, the range of modeling and the modeling depth should be effectively specified. Also, an effective auditing mechanism should be instituted to ensure that the model and information within it can be effectively used as needed.

Information about the attributes of the BIM model component is insufficient. The way information is stored and retrieved must be improved because under ideal conditions, the BIM model would be used throughout the entire life cycle of the project. The information is used constantly from design to construction and to the later operation and maintenance stage. Most of the model component information is default information which comes with the software. The information content contained is far less than the late operational and maintenance application requirements. Therefore, in the different stages of the project, clarification is necessary in the content of a model's component information, the responsible subject of information input and maintenance, and the component information storage need to be considered.

There are breakthroughs in BIM standards, but these must be continually improved. At the early stage of BIM implementation in Shanghai Tower, there were no national or local BIM standards, even standards of project level were rarely heard of. Therefore as the owner, we needed to set up relevant BIM regulations and standards according to the features and requirements of the project. Meanwhile, we needed to communicate with every participant involved with the specific BIM application processes and implementation standards in order to ensure the feasibility of the standards. As the years went by, we have formed a series of BIM technology

使用的效果亦将受到影响。因此在项目前期需要对BIM模型的建模规则、建模范围、建模深度做有效的规范，同时建立行之有效的审核机制，确保模型及信息能够被有效地使用。

BIM模型构件属性信息不够完善，信息存储、调用方式有待完善。理想的状况下，BIM模型可贯穿项目的整个生命周期，其信息是要从设计到施工、再到后期运行维护阶段，被不断地延续使用下去的。而大部分的模型构件信息均为软件自带的默认信息，其所包含的信息内容远达不到后期运维的应用需求。因此需要考虑在项目不同的阶段明确模型构件信息的内容，信息录入及维护的责任主体，构件信息的存储、调用方式，以及对信息的编辑、备份管理等。

BIM标准已有突破但需持续完善。上海中心初期进行BIM实施时，不仅国家和地方标准没有出台，可参考的项目级标准都鲜有听闻，只能参考国外的相关BIM标准。所以作为业主方，我们需要根据项目自身的特点和需求，制定相应的BIM标准和规范。同时与项目各参与方沟通具体的BIM应用流程和实施标准，以确保BIM标准的可实施性。随着这几年的积累，我们已形成了一系列过程中的BIM技术应用标准。而随着工程竣工验收的到来，也在逐步形成各专业的BIM竣工交付标准。同时，国家和地方标准也陆续出台，如由中国建筑标准设计研究院承

| Softwares<br>常用软件 | | | Discipline<br>使用专业 | Data Format<br>常用数据格式 | General Format<br>通用格式 |
|---|---|---|---|---|---|
| Modeling<br>模型搭建 | AutoCAD | | All disciplines<br>全专业 | .dwg | IFC |
| | Autodesk Revit | Architecture | Architecture, secondary structure, outter curtain wall, elevator, lift, interior finishes<br>建筑、二结构、外幕墙、自动扶梯、垂直电梯、室内装饰 | .rvt | |
| | | Structure | Structure 结构 | | |
| | | MEP | Mechanical and electrical pipelines, facilities<br>机电管线、设备 | | |
| | Rhino | | Inner curtain wall, podium curtain wall<br>内幕墙、裙房幕墙 | .3dm | |
| | Tekla | | Steel structure<br>钢结构 | .db1 | |
| | Solidworks | | Window washer<br>擦窗机 | .sldprt | |
| Integrating<br>模型整合 | Navisworks | | All disciplines<br>全专业 | .nwd | |

Table 5.2. Data format of BIM application software
表 5.2. BIM应用软件数据格式

application standards. With the arrival of the project completion acceptance, BIM delivery standards of every discipline will also have been set up gradually. At the same time, national and local standards are developed as well, such as "BIM delivery standard for construction design," and "BIM classification coding standard for construction design" that were mainly spearheaded by China Institute of Building Standard Design & Research. The initial draft of "Construction BIM application general standard" by China Academy of Building Research has also been completed. This means we will have a general reference standard when implementing BIM in the project. We can also quantify the economic costs caused by communications among different companies and staff. We hope these standards will be developed as soon as possible, to help BIM implementation in future projects.

担编制的BIM国家标准——《建筑工程设计信息模型交付标准》、《建筑工程设计信息模型分类编码标准》即将完成，而中国建筑科学研究院会同有关单位编制的《建筑工程信息模型应用统一标准》也已完成征求意见稿，这就意味着今后我们的BIM实施可以有统一的参考标准，从而节省大量不同单位，不同人员之间沟通的成本。希望这些标准能尽快出台并完善，并对项目的BIM实施产生帮助。