Implementation of Building Information Modelling (BIM 3D) on the Steel Building project: Case study of the 3-storey building GKJ MARGOYUDAN

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Abstract. Building Information Modelling (BIM) is a technological revolution developed in the construction industry. The implementation of BIM using Tekla Structure software helps overcome problems in the 3-story steel building construction project. Integration of the structural analysis software and Tekla Structure BIM, making the design phase efficient. Detailed drawings generated at the design stage using analysis software and BIM, lead to efficient construction exploration and evaluation. Tekla Structure produces detailed drawings and a list of required materials, which can help contractors in project management. Simultaneous management of activities between site and workshop, providing the advantage of project completion on schedule. Procurement of materials and errors during construction can be minimized, thereby optimizing project costs.

Keywords: BIM, building, steel, structure

1. Introduction

The technological revolution is developing progressively, driving enormous changes in the construction industry. The technological revolution makes construction activities efficient, mistakes are avoided, on time, costs and construction quality is better. Projects in the construction industry that implement the technological revolution have been able to assist construction activities by reducing errors and solving various problems [1]. The technology in the construction industry that has been developed and implemented is building information modeling (BIM). Building information modeling (BIM) is a system or technology that includes some important information in the design, construction, maintenance process that is integrated and visualized on different software in 3D modeling [2], [3].

Project planning by applying the BIM concept can be used as an alternative, this can simplify project management arrangements. BIM (Building Information Modeling) is an approach to building design,

construction, and management. The scope of BIM supports all stages of the project such as; design projects, schedules, and information more efficiently. Such as architecture, structural models, MEPI (mechanical, electrical, piping & instrument), site plans, material or material requirements, and the ability to visualize [4]. In addition, BIM is also able to transform the potential for clashes at the design and construction stages. Potential clashes are reviewed based on size and space, movement of goods mobilization, types of materials, equipment and other resources.

The complexity of the project makes it difficult to understand, predict, and control its overall behavior, even when given fairly complete information about the project system. So that it encourages innovations in work methods, which have an impact on design and construction materials. Some projects that do not allow to be applied with reinforced concrete; steel structures are an alternative to be considered. However, the use of steel structures as building materials has its own complexities. Steel structure projects consist of factory-made components or units that are transported and assembled on site, which go through the following processes: (i) planning, (ii) design, (iii) fabrication, (iv) transportation, and (v) structure erection.

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The fabrication method provides advantages to the construction industry, among other efficiency schedules and implementation [6]. The steel fabrication stages in the workshop can be carried out in parallel with civil works (soil and foundation works) on site. Soil and foundation work has been completed and ready, steel structure erection can be carried out immediately without delay. Therefore, it is possible for contractors to implement prefabricated methods on complex projects [7]. Implementation of prefabrication using BIM Tekla Structure on steel structure construction helps reduce the risk of material wastage and rework due to errors.

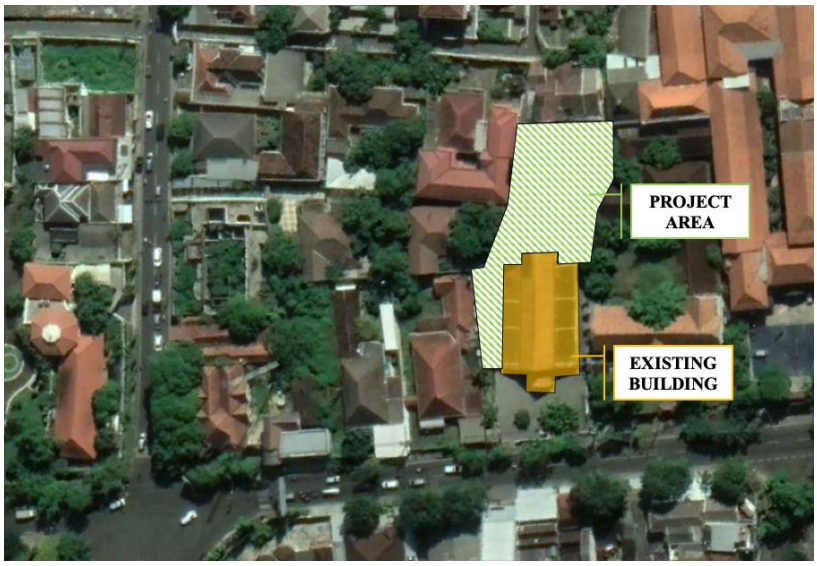

Figure 1. Project layout

The 3-story building project GKJ Margoyudan, has complexity in the implementation of construction in a limited project area, activities in existing buildings (cultural heritage buildings), and crowded environments. Therefore, the selection of steel structure construction is an alternative to minimize

potential problems that may occur. **Figure 1** presents the project layout. Steel structure construction carried out by the fabrication process at the workshop and delivery management for erection, is able to minimize the impact on existing buildings from vibration and pollution when using reinforced concrete (reinforced concrete columns and beams). Implementation of Building Information Modelling (BIM) using Tekla Structure on the GKJ Margoyudan 3-storey building project can help complete the project according to schedule and quality.

2. Implementation of BIM on Steel Structure Building

Measurement and testing are carried out at an early stage to determine site conditions as the basis for the design stage. Measurement of the project site area, soil testing and traffic impact analysis are the preliminary design parameters. The design stages are as follows:

1) Conceptual Design of Steel Buildings
2) Structural Analysis and Detailed Design
3) Detail Design Building Information Modelling
4) Detail Fabrication

3. Conceptual Design of Steel Buildings

The design concept plays an important role in a building design. The design concept becomes a basis for guiding designers to develop an idea so that it becomes a concept and can be realized. The design concept is based on the ideas of the owner, guided by the rules and principles of architectural design [8]. The design concept in this study, the architectural design concept considers several factors, i.e. the location of the building, the function of the building, lighting, the concept of comfort, etc. This design concept that has been compiled will produce an architectural design, as shown in **Fig 2**.

Meanwhile, the concept of structural design in the GKJ Margoyudan building considers constructable in the construction phase. Structural design criteria are based on the type of structural material (concrete and steel), structural system, design code, etc.

Figure 2. Architectural Design

4. Structural Analysis and Detailed Design

Structural analysis is the process of calculating and determining the effects of loads and internal forces on a structure, building or object [9]. Structural engineers perform structural analysis using software in the form of SAP2000 for analysis of structural elements. The structural elements must have the ability to respond to loads and displacements that occur. Structural analysis modelling using software is shown in **Fig 3**. Integration between SAP2000 and Tekla Structure can be done directly, by expor files in SDNF format and import files in cis/2 or ifc format.

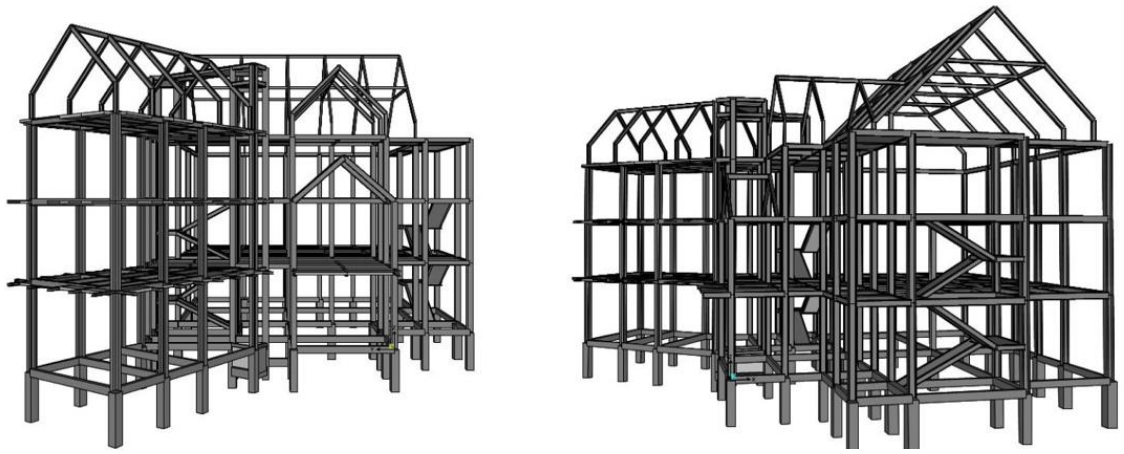

Figure 3. Structural Analysis Model

The detailed design of the steel structure requires detailed calculations, such as the details of the connection of beams, beams, columns, and baseplates. Detail calculations are calculated based on the internal forces that occur compared to the capacity of the structural elements. The connection detail design was calculated using IDEA Statica software. The quantity and type of connection in steel structures are many, the use of software provides the advantage of time and efficiency. **Figure 4** presents an analysis of steel connection detail.

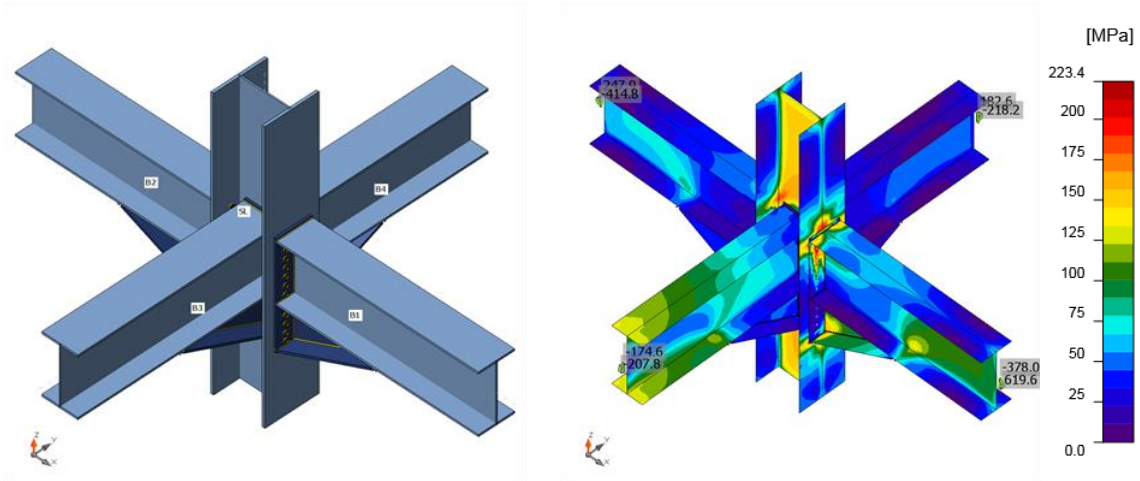

Figure 4. Analysis of steel connection details.

5. Detail Design Building Information Modelling

The results of the structural analysis have confirmed that the structural elements have the ability to respond to the design load. Furthermore, the structural analysis modelling is detailed into a detailed engineering design product. Detailed engineering design is modelled using Tekla Structure software. It

is designed by exporting structural analysis modelling files (SAP2000) to Tekla Structure software. **Figure 5** presents an isometric drawing of Tekla Structure modelling.

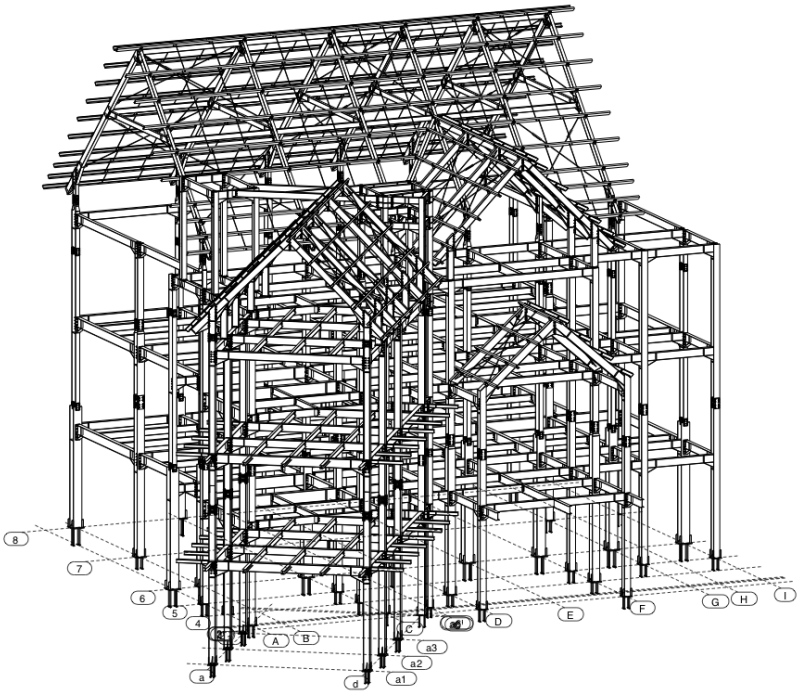

Figure 5. 3D Isometric Drawing

Modelling in Tekla Structure is rearranged to adapt to the geometry of the architectural design, by updating the position of structural elements, spans, elevations, etc. The connection details of structural elements that have been previously analysed are also detailed in Tekla Structure modelling, such as beam-to-column, beam-to-beam, and baseplate. Tekla Structure has provided component templates for various types of connection such as columns, beams, bracing elements, fastening elements, etc [10]. **Figure 6** shows a catalog of steel connection components in Tekla Structure.

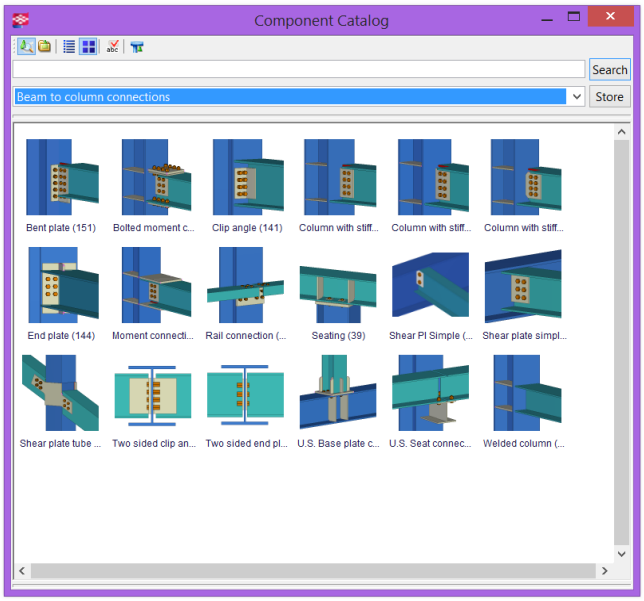

Figure 6. Tekla Structure Components Catalog Of Steel Connection

6. Detail Fabrication

Detailed engineering design using Tekla Structure software provides advantages at the engineering and construction (fabrication) stages compared to conventional (2D) drawing designs.

Design details that have been calculated and modeled on Tekla Structure, become a single part drawing of the structural elements. Single part is a workshop drawing to show detailed part information. Single part not only facilitates the fabrication process for contractors, it is also useful for quality control of the fabrication process [11]. **Figure 7** presents a single part of column and beam elements.

Furthermore, the output of Tekla Structure is a material list document. The material list contains detailed information about raw materials based on the type and quality of the material. This document is used as a material procurement document for the fabrication process and the erection process on site. Detailed and accurate information from the material list document has an impact on project costs to be efficient and controllable. The material list is presented based on dimensions, profile shape, and bolt diameter. **Figure 8** presents a sample material list and bolt list.

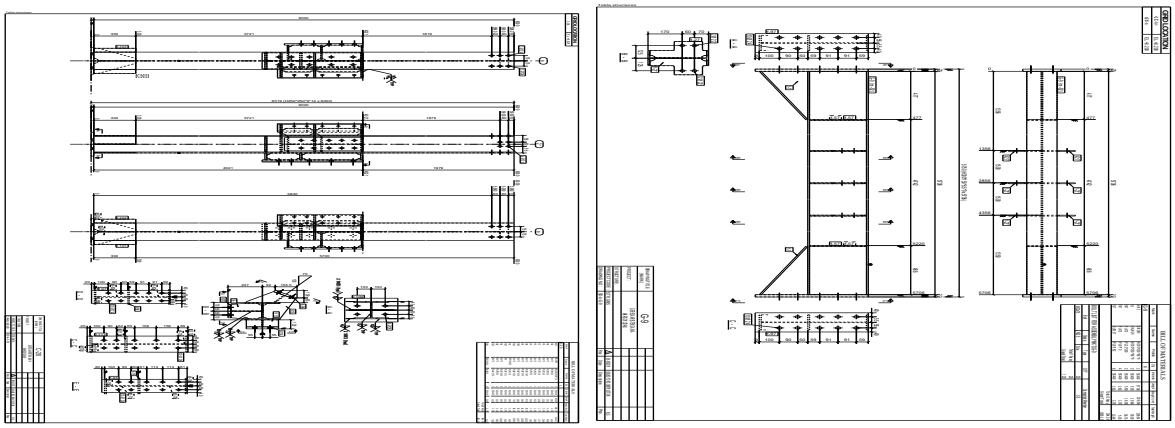

Figure 7. Single part of column and beam elements

MATERIAL LIST BY SIZE

PROJECT : GEREJA KRISTEN JAWA
STRUCTURE : STR.GMS — Modeled By :
PROJECT CODE: — Created Date : 01.09.2018

SIZE	GRADE	QTY	LENGTH	AREA(m2)	WEIGHT(kg)
H200*100*5.5*8	SS400	6	5697,64	4,39	121,48
H200*100*5.5*8	SS400	2	4155	3,2	88,59
H200*100*5.5*8	SS400	1	4120	3,17	87,84
H200*100*5.5*8	SS400	2	3555	2,74	75,79
H200*100*5.5*8	SS400	1	3520	2,71	75,05
H200*100*5.5*8	SS400	6	2855	2,2	60,87
H200*100*5.5*8	SS400	3	2830	2,18	60,34
H200*100*5.5*8	SS400	3	2830	2,18	60,34
H200*100*5.5*8	SS400	3	2830	2,18	60,34
H200*100*5.5*8	SS400	3	2830	2,18	60,34
H200*100*5.5*8	SS400	3	2830	2,18	60,34
H200*100*5.5*8	SS400	1	2830	2,18	60,34
H200*100*5.5*8	SS400	1	2830	2,18	60,34
H200*100*5.5*8	SS400	1	2830	2,18	60,34
H200*100*5.5*8	SS400	3	2820	2,17	60,12
H200*100*5.5*8	SS400	2	2817,5	2,17	60,07
H200*100*5.5*8	SS400	2	2817,5	2,17	60,07
H200*100*5.5*8	SS400	2	2817,5	2,17	60,07
H200*100*5.5*8	SS400	3	2396,55	1,85	51,1
H200*100*5.5*8	SS400	2	1486,38	1,14	31,69
H200*100*5.5*8	SS400	12	860,23	0,66	18,34
		TOTAL	171166,01	131,8	3649,36
H200*200*8*12	SS400	1	6000	6,96	299,23
H200*200*8*12	SS400	1	5456	6,33	272,1
H200*200*8*12	SS400	1	4718	5,47	235,29
H200*200*8*12	SS400	5	3978	4,61	198,39
H200*200*8*12	SS400	2	3377,5	3,92	168,44
H200*200*8*12	SS400	1	3375	3,91	168,31
		TOTAL	46194	53,59	2303,74

BOLT LIST

PROJECT : GEREJA KRISTEN JAWA
STRUCTURE : STR.GMS — Modeled By :
PROJECT CODE: — Created Date : 01.09.2018

NO	GRADE	DIAMETER	X	LENGTH	QUANTITY	Site/Shop
1	A307	12	x	30	948	Site
2	A325	16	x	55	396	Site
3	A325	16	x	60	732	Site
4	A325	16	x	65	360	Site
5	A325	20	x	50	459	Site
6	A325	20	x	55	92	Site
7	A325	20	x	60	83	Site
8	A325	20	x	65	210	Site
9	A325	20	x	70	70	Site
10	A325	20	x	75	80	Site
11	A325	22	x	55	179	Site
12	A325	22	x	60	3	Site
13	A325	22	x	65	230	Site
14	A325	22	x	70	1064	Site
15	A325	22	x	75	1822	Site
16	A325	22	x	80	554	Site
17	A325	22	x	85	240	Site
18	A325	22	x	90	180	Site
19	A325	22	x	95	320	Site
20	A325	24	x	75	20	Site
21	A325	24	x	80	100	Site
22	A325	24	x	85	60	Site
23	A325	24	x	100	30	Site
24	A325	24	x	110	10	Site
				Total:	8242	

Figure 8. Material list and bolt list

7. Conclusion

This paper shows how the successful implementation of Tekla Structure BIM helps in planning and development in limited locations, environmental activities, and other problems. Structural analysis software combined with implementing Building Information Modelling (Tekla Structure), project planning and construction becomes efficient. The fabrication and erection process on site can be controlled for quality, from the beginning until the project is completed.

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