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Hybrid System Methods in Industrialised Building Systems (IBS): A Structural Compatibility Study

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ABSTRACT

Hybrid System in Industrialised Building System (IBS) is combining IBS components with conventional method. Delay has become a familiar issue in construction field. The issues pertaining structure stability when using this combination method leads to delay while installing these two different method components. The combination also could cause a defect jointing. In Industrialised Building System (IBS), even though it is one of the technology methods that can save times, cost, and reduce labour in construction, but there still have constraints such as design issues, lack of experienced worker, and internal and external issues that can affect cost problems. In this study, the suitability structure based on combination method is investigated to discover the affected factors of suitability structure by using Hybrid System which is the aim of this study. The data analysis from quantitative survey shows that the top three affecting the building structure are: 1) weather effects with highest mean of 6.25 followed by 2) delay of jointing process at 6.03 and 3) defects from monolithic jointing at 5.93. Therefore, the amount of average data obtained shows that the most affected structure is the Hybrid System.

1. Introduction

Construction industry is in need of a highly technological construction method or system for the simple aim of giving it a push it deserves. In Malaysia this technologically enhanced method is known as the Industrialised Building System (IBS) [19]. Generally, IBS hybrid means a combination of two different elements as stated in Azmin and Umar [12]. The elements can be any types of things that can be mix or combine in order to form one rigid component. The combination in either methods or elements for engineering and construction has been used for the innovations nowadays as our

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technologies grows. Hence, this combination known as a hybrid. A hybrid is also anything that is a mixture of two or more things in Cambridge Dictionaries [11], something that is a combination of two different things, so it has qualities relating to both of them. According to Azmin and Umar [12] hybrid is a combination of the same component from IBS and conventional in-situ method. For example, beam structure has been combined between IBS precast and cast in-situ. Thus, it is called a Hybrid System because of using a similar component with a two-way method to attach together. Hybrid project management is a recent discovery that can help contractors and project managers to implement new techniques by combining them in a hybrid way in project management by Abu Bakar *et al.*, the term 'hybrid concrete construction' (HCC) is used to describe the combination of concrete construction methods, e.g., in-situ concrete and precast concrete, with one another or with other materials, e.g., steel. Although it could be argued that most buildings employ such combinations, HCC is the deliberate integration of different construction techniques to achieve a cost, speed or other performance benefit, Jacqueline Glass [8].

1.1 Hybrid System

Van der Laan *et al.*, tracked down that in their exploration, stock control by utilizing Hybrid System with PUSH control technique where the returned items are remanufactured as right on time as could really be expected and PULL control procedure which the returned items are remanufactured as late as could be expected. The Hybrid System for both the yield of assembling and remanufacturing cycle can be utilized to satisfy client's interest. Figure 1 shows their Hybrid System.

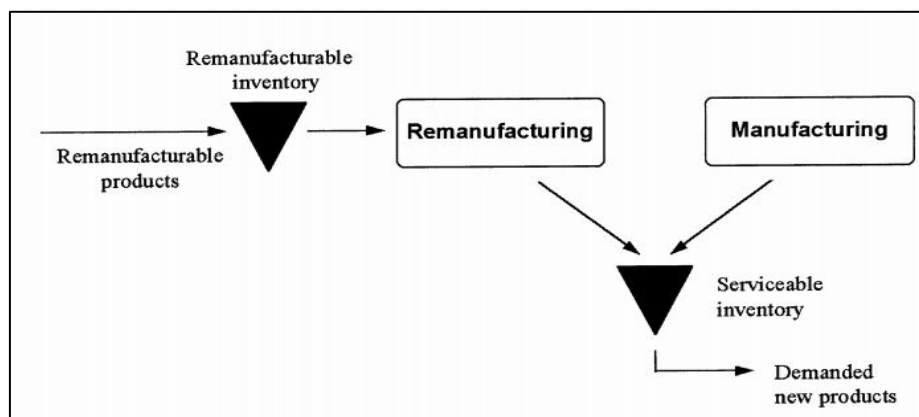


Fig. 1. A Hybrid System with Manufacturing and Remanufacturing Operations, and Stocking Points for Remanufacturables and Serviceable (Van der Lan *et al.*,)

In the United Kingdom, a model of Best Practice for Hybrid Concrete Construction (HCC) appeared in Table 1 had been created by Glass [18]. The model comprises of 8 phases beginning from instructions until development 2. The creator additionally records down the best practice or basic achievement factors in each stage that should consider with respect to in carrying out Hybrid Concrete Construction it.

Table 1

The Best Practice for Hybrid Concrete Construction (HCC) (Glass [8])

Construction Stage	Best Practices for HCC
Briefing: Demonstrate the need	i. Knowledge Management - Information sharing among project stakeholders for comprehensive Client Needs
Feasibility Study: is it worth doing	i. Trust/building confidence: To convinced project stakeholders ii. Evidence – Quantity Surveyor (QS) prepared holistic costing iii. Knowledge Management – Shared the advantages of HCC/IBS
Conceptual Design 1: consider the options	i. Trust/building confidence – Main Contractors and HCC/IBS providers and Sub- cons ii. Evidence – Thorough QS Analysis on Costing and Viability iii. Manufacturability & Build ability - Practicality on site iv. Trust / building confidence- Transparency and ‘open book’ of advantages of HCC/IBS. Project Architect must ‘champion’ the promotion HCC/IBS
Conceptual Design 2: choose the options	i. Evidence – Visit the similar completed building/projects ii. Knowledge Management – Strategies the appropriate devices for project stakeholders to share the information. Proposed performance indicators iii. Manufacturability & Buildability – Establish interface registration as management tools of risk management iv. Buildability – Lead time project planning for cost and time management v. Trust/building confidence: Client feedback being considered in Client Brief/Needs document
Design 1: Work up chosen option	i. Evidence – Produce component samples, prototype and model of HCC/IBS ii. Knowledge Management – Generate ‘Concrete Frame Profile’ (IBS Supply Chain Management), iii. Manufacturability & Buildability – Improved repetition/mould user ability iv. Buildability –Realistic tolerances between IBS producers and project designers, Use Virtual Reality (VR) for managing the planning of projects v. Knowledge Management – Agree on the communication strategy for On Site decision-making
Design 2: Production Information	i. Manufacturability & Buildability- Take advice from precaster/IBS Suppliers ii. Buildability – Optimised hook time for crane on site, Devised strategy to protect IBS providers, set not to allow ‘unauthorised’ IBS providers to modified/ remedies IBS components
Construction 1: Off-site Manufacture	i. Buildability – Carry out final Virtual Reality (VR) for Simulation manufacture, erection and complete construction process
Construction 2: On-site work	i. Knowledge Management – As built building Survey to be shared for whole project stakeholders in HCC/IBS

Hybrid system construction in this study is a thing made by consolidating two unique components by Oxford Dictionary [9]. In this undertaking, cross breed is a mix of a similar part from IBS and customary in-situ strategy. For instance, pillar structure has been joined between IBS precast and projected in-situ. Example of the Hybrid system in the construction as Figure 2.

Hybrid construction uses special building technologies to deliver high-quality, sustainable buildings on a smaller budget and in less time. Quite effortlessly, new technologies combine concrete construction and traditional steel with precast concrete elements that are manufactured in a controlled environment (Tim Anderson [17]).

To combine the advantages of these two construction methods: the modern one with its better mechanical performance and economic efficiency, and the traditional one with its insulating power, ecological and bioclimatic aspects, it is proposed to investigate the aspects of the concept “hybrid building technology” which is less polluting, competitive and capable of reducing the impact of the

construction on the environment by Belabid *et al.*, [3], according to An Xu, Shumin Li *et al.*, [1] frame structure optimization is a design problem posed to find an optimized structural member layout and the most suitable cross-sectional size according to the design requirements.

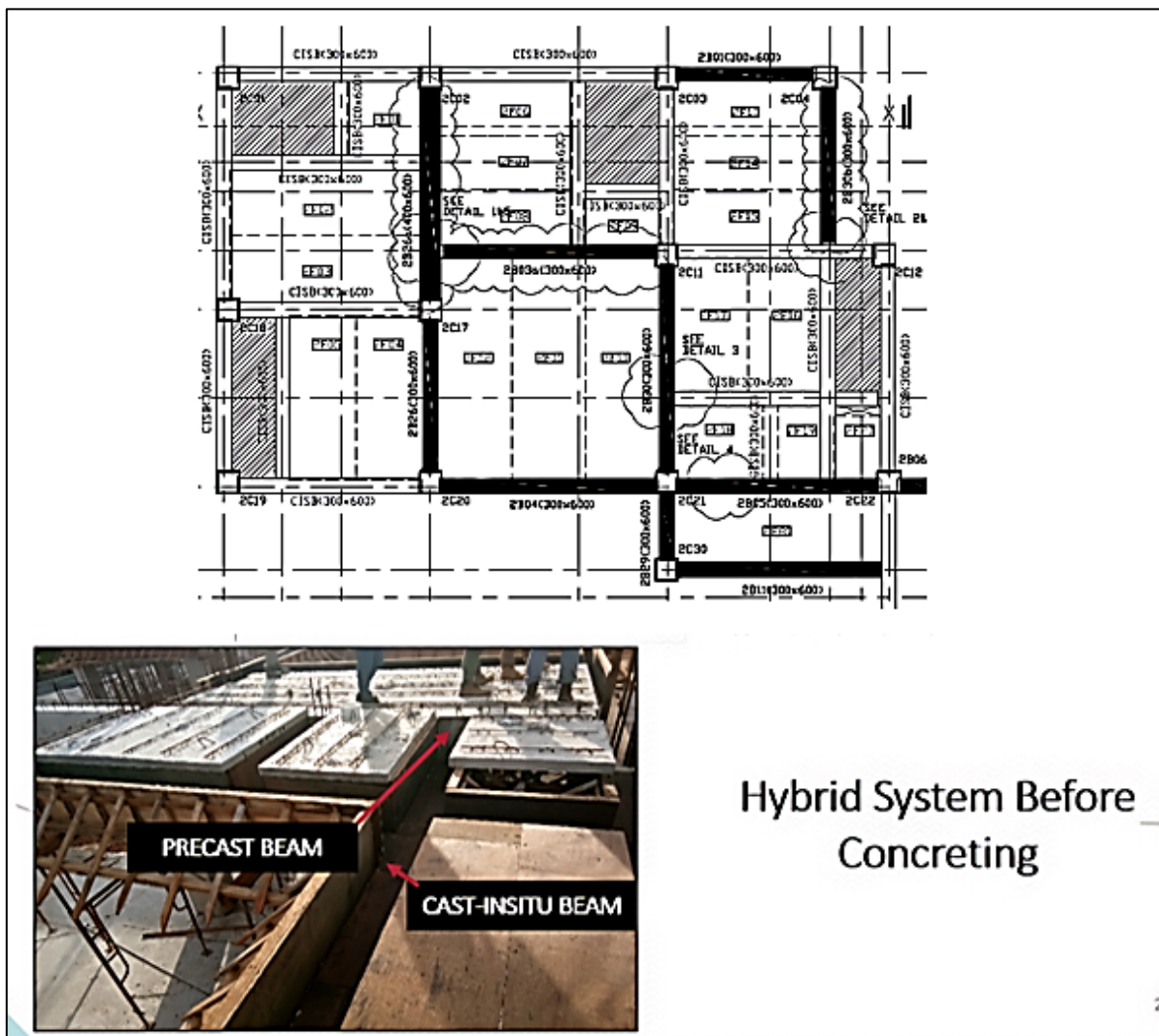
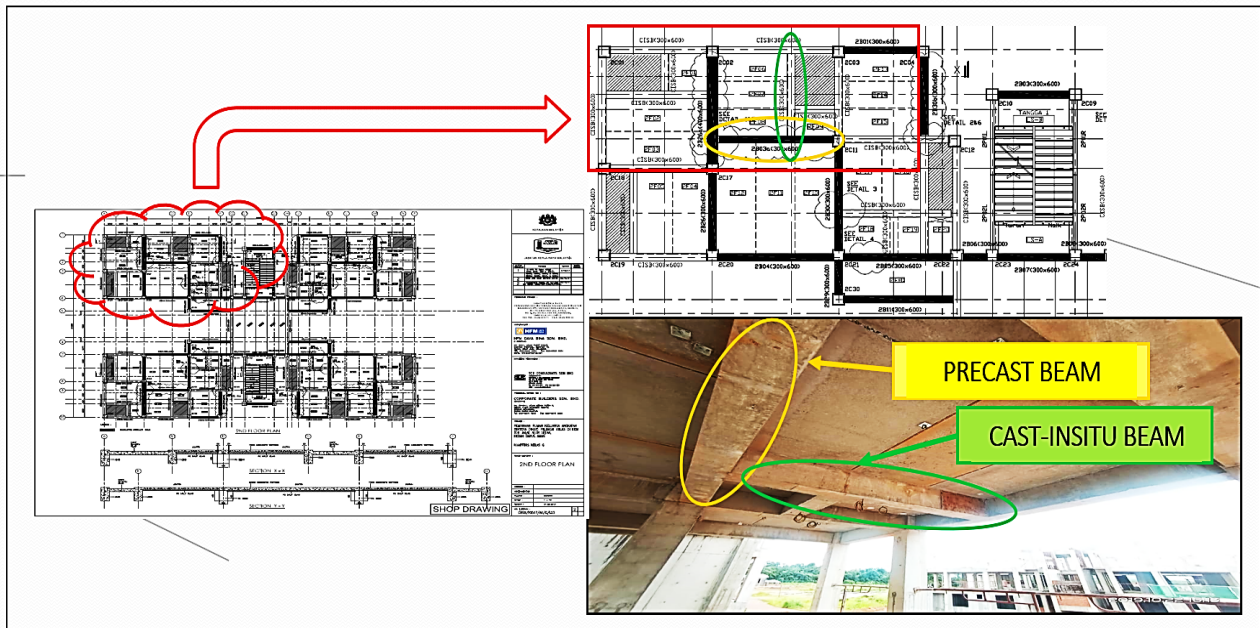


Fig. 2(a). Hybrid System Before Concreting



Hybrid System After Concreting

3

Fig. 2(b). Hybrid System After Concreting

1.3 Mixed System

Development these days has begun the new technique which is stir up the regular and industrialized Building (IBS). In past, at the beginning phase of IBS inclusion in development industry, individuals generally utilized 100% IBS part beginning from ground floor segment to the highest point of rooftop bracket.

Hybrid materials use a combination of wood, concrete and steel to provide a cost-effective and sustainable solution to building structures as well as options to improve building performance and design. Hybrid construction is the combination of different materials or techniques to design a range of building types. Often, a hybrid system will require prefabricated elements to be manufactured off site. Mixed System is described by the usage of explicit segments that are systematized and fabricated in the modern office while others are tossed in situ at the structure areas. This incorporates the social event of precast segments, for instance, in-filled dividers, bathrooms and flights of stairs which are solidified into the guideline units at the structure districts. Floors, Slabs, segments and shafts are given in situ a job as these are by and large less complex and less dreary bits of the errand by Badir *et al.*, [2]. The Mixed System, in this examination is considered as a blend of the IBS and the Conventional Construction strategies by Lachimpadi *et.al.*, [13]. Figure 3 below is example of mixed method technic.

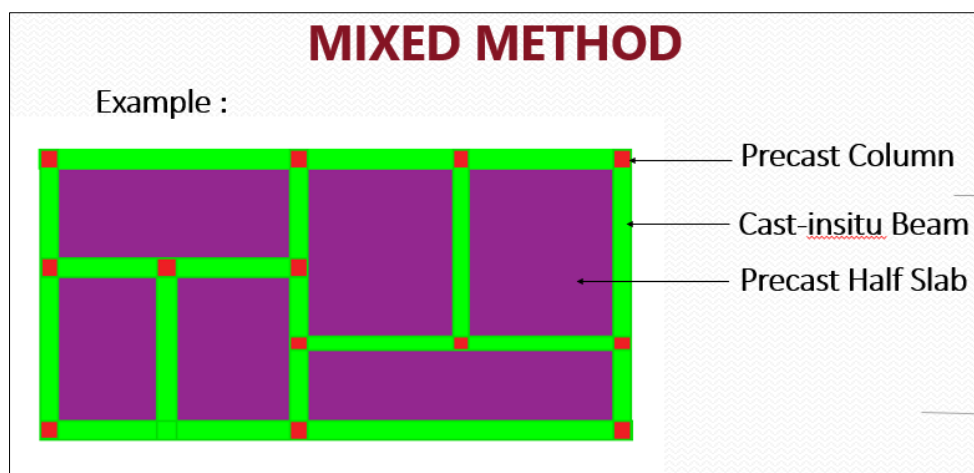


Fig. 3. Example of Mixed Method

1.4 Structure (Jointing Issue)

Malaysia is a country with a tropical environment. Such nations regularly experience weighty precipitation during the rainstorm seasons each year. This prompts the issue of spillages which is a significant issue looked by structures developed utilizing IBS applications. At the point when a spillage shows, different difficulties might follow and these incorporates sodden, erosion, etc by Mydin *et al.*, [14].

Construction Industry Development Board Malaysia [6] finds out the serious issue with IBS framework is that the workers for hire are poor in workmanship when introducing pre-created parts at building site. This can mess up the end joints, thus came about water breaks and blemishes. To resolve this load of issues, the fashioners need to tirelessly inspect completely the completed units upon handover to check that the engineer tended to all abscond works. The two joining techniques i.e., adhesive bonding and mechanical fastening combined are termed as hybrid joints, Mahesh J. Patil *et al.*, [16]. Another issue related to pre-created parts is that the IBS framework is considered as no compromise modification. Most people may need to create an opening for the divider apparatus or perhaps insert another element as a divider (CIDB).

However, on the positive side, in the redesign work there may be modification work to provide additional channels and new electrical wiring where it may affect the framework or certain parts. This sort of thing might be an issue in trying to destroy a certain divider to join two units or add a unit if the units are joined to each other [20]. The insufficiency of techniques and instruments in the developments characterizing a worth. The central matter is to foster a standards or rules for architect's choices making when utilizing the framework. Each economical rules execution should be address to settle the secret possibilities of carrying out IBS development framework by Yaman *et al.*, [21]. The pre-loaded hybrid joint optimally combines the specific advantages of both elementary joining methods and thus creates an efficient structural joint, Christian Denkert *et.al.*, [5].

This paper reviews about to discover the suitability for structure by using Hybrid System method in Industrialised Building System (IBS) construction. The finding data will conclude the suitability of structure and suggest a recommendation to enhance a better way in future for Hybrid System.

2. Methodology

The methodology of this study is using the quantitative method by using survey questionnaire in order to discover the issues yet to be known. The answer from gathered questionnaires will be the

data for this issue. Hence, it will become a guideline to come out with the recommendation for future study. Figure 4 shows the methodology for this study.

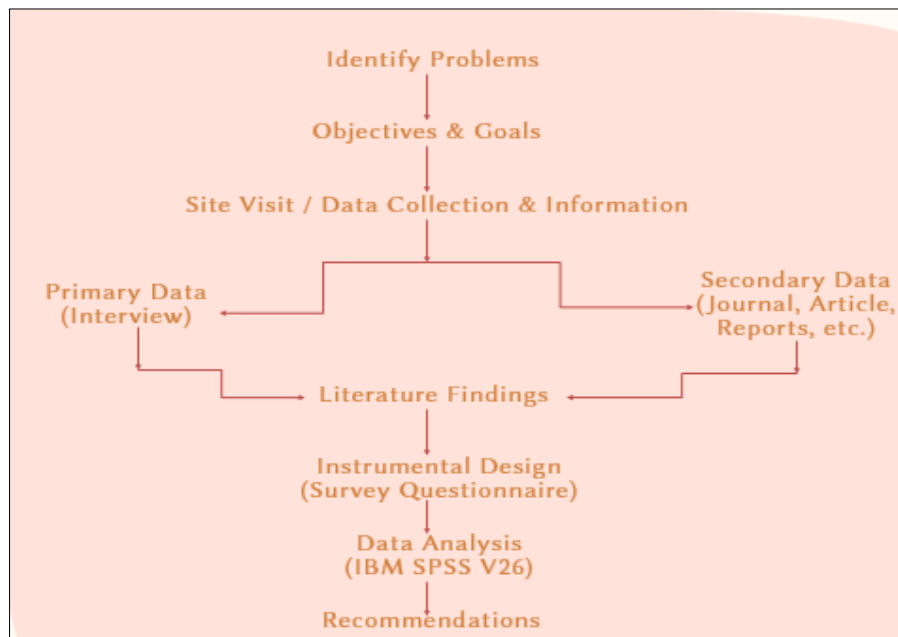


Fig. 4. Methodology of Study

By using a professional respondent such as the project manager, civil engineer, site engineer, specialist IBS, and site supervisors with more than five years experiences have make the data bring out a valid result among experiences respondents. Furthermore, the data also evaluate by IBM SPSS Version 26 for the accurate results. The suggestion for future study also can highly be seen.

3. Results and Data Analysis

By utilizing recurrence conveyance information and utilizing the all-out intend to distinguish the outcomes as displayed in the diagram bar underneath. This will be recognized by the most noteworthy mean is the most unsatisfactory justification for the design and part by utilizing Hybrid System. The normal scale will sort with the pace of strongly unaffected, mostly unaffected, unaffected, neutral, affected, mostly affected, and strongly affected. By following seven points Likert scale by Sorrel Brown (2010), the scale will be assess as displayed in Table 2.

Table 2

Mean Average Score for Suitability

Mean Average Score	1.00-1.49	1.50-2.49	2.50-3.49	3.50-4.49	4.50-5.49	5.50-6.49	6.50-7.00
Description	Strongly Unaffected	Mostly Unaffected	Unaffected	Neutral	Affected	Mostly Affected	Strongly Affected

The most noteworthy mean from the Figure 5 above implies the most unacceptable justification behind the construction and part by utilizing Hybrid System at 6.25 in light of the fact that the strategy for Hybrid System relates a great deal with the climate impact since the customary part needs to go through the developed stage for the cementing works. The blend (ordinary + IBS) delay jointing measure follows at 6.03 as we worry that the jointing system do take a deferral since after the

establishment of IBS part, we need to trust that the customary part will prepared before continue for the entire interaction to be proceeded.

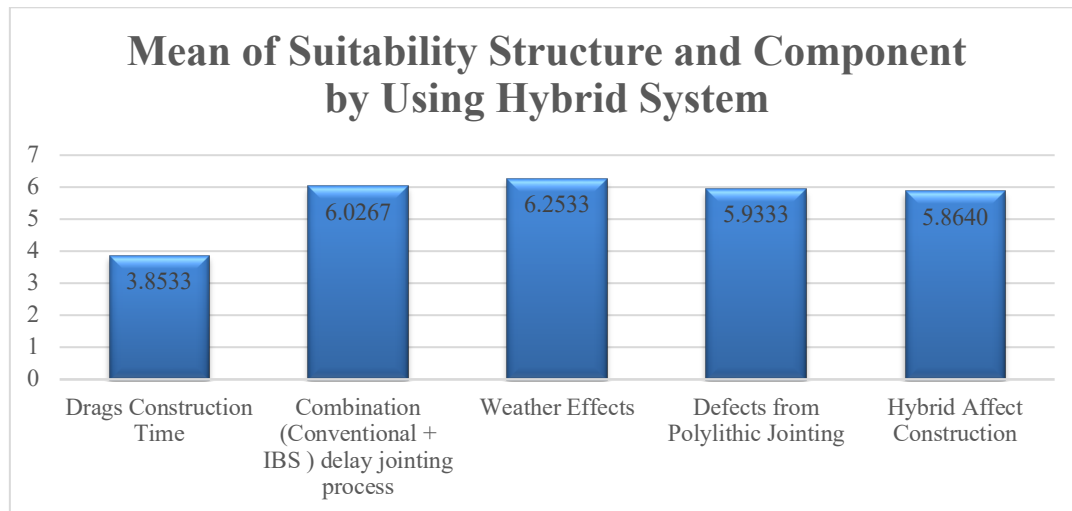


Fig. 5. Mean of Affected for Suitability Structure and Component by Using Hybrid System

Then, the deformities from polyolithic jointing are at 5.93 since in Hybrid System, polyolithic jointing happens when IBS part will joint with the traditional part and it causes the imperfections at the jointing. While for the Hybrid influence development, respondents feel that it is influenced at 5.86 mean as a result of different explanation that occur all through the cycle. What's more, the least is the hauls of development time at 3.85 since the general cycle is really partakes on hauling the development time as notice in the factor of postponement by utilizing Hybrid System.

Subsequently, for this examination, we can finish up the appropriateness of construction and part by utilizing Hybrid System are as displayed in the Table 3. The general mean reach for the parts to discover the reasonableness design and part by Using Hybrid System shows it is for the most part influenced the appropriateness. At the end of the day, it implies that the outcomes connotes that the construction and part are unsatisfactory by utilizing Hybrid System dependent on the parts that have been broke down. Most respondents additionally by and by remarks that Hybrid System convolutes the entire ventures and hauls the hour of development. Respondents from related construction organization is about 90 professional peoples such as project managers, engineers, site supervisors, and specialists will involve from three projects in this case study.

Table 3
 Summary of Mean Range Suitability Structure and Component by Using Hybrid System

Component	Mean Range	Affected
Drags Construction Time	3.85	Neutral
Combination Delay Jointing Process	6.03	Mostly Affected
Weather Effects	6.25	Mostly Affected
Defects From monolithic Jointing	5.93	Mostly Affected
Hybrid Affect Construction	5.86	Mostly Affected
Total	5.58	Mostly Affected

4. Conclusion

In conclusion, from the results data that had been gathered, it shows that all components that have been point out are mostly affected the suitability structure in Hybrid System of Industrialised Building System (IBS). Hence, there is a recommendation to minimize the issues of jointing for the structure.

- i. A better design drawing for fast completion timeline: Hybrid System is a good innovation method that tried to be implemented. However, it needs a better design drawing so that it can much saves on time since IBS project is known as a fast completion project. Figure 6 shows the propose design in order to shorter the time of installation IBS components and cast the conventional method.

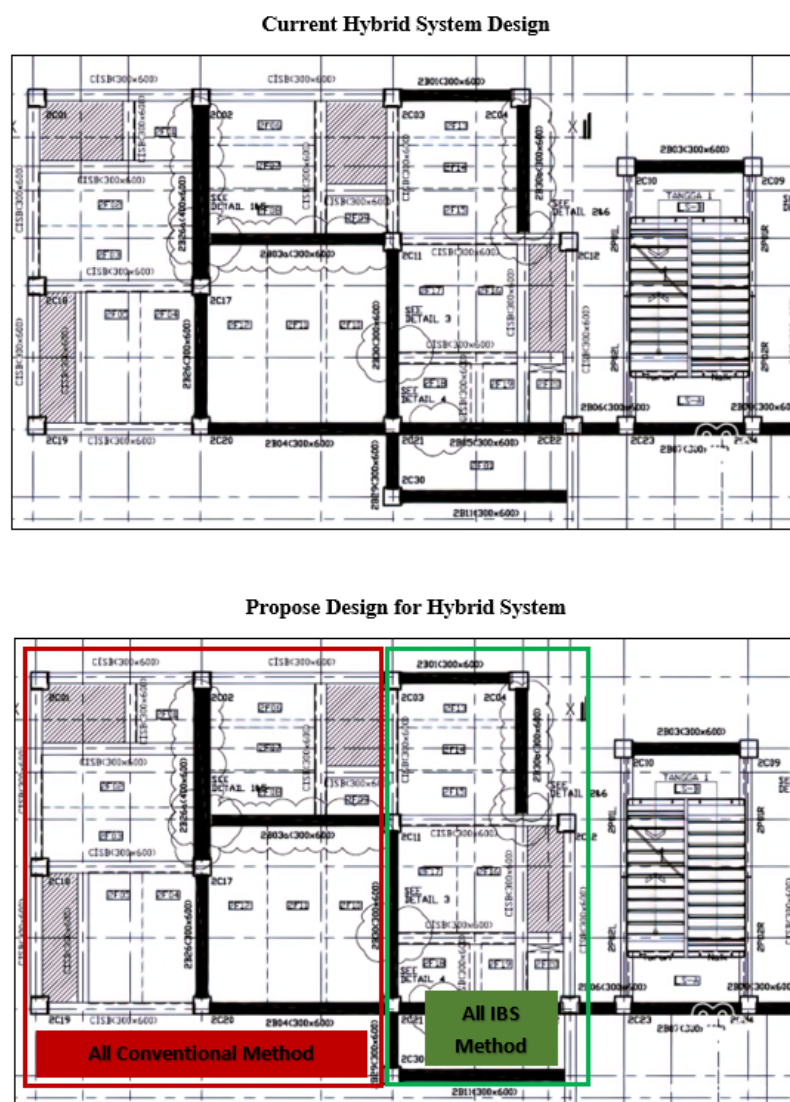


Fig. 6. Suggestion for Future Study

- ii. A structure combination design to avoid jointing defects that leads to delay: The structure design for the Hybrid System should have been attached with better combination in order to get a better quality of structure in future and avoids defects from the jointing of different combination components. Hybrid System method produced a monolithic

jointing since it is from two different component joints together. Thus, if the design can be revised to minimize the monolithic jointing, Hybrid System may produce better quality with less defects of jointing as shown in figure below, how the monolithic joints work thus can prevent any delays from this issue.

- iii. A structure combination design to avoid jointing defects that leads to delay: The structure design for the Hybrid System should have been attached with better combination in order to get a better quality of structure in future and avoids defects from the jointing of different combination components. Hybrid System method produced a monolithic jointing since it is from two different component joints together. Thus, if the design can be revised to minimize the monolithic jointing, Hybrid System may produce better quality with less defects of jointing as shown in figure below, how the monolithic joints work thus can prevent any delays from this issue.

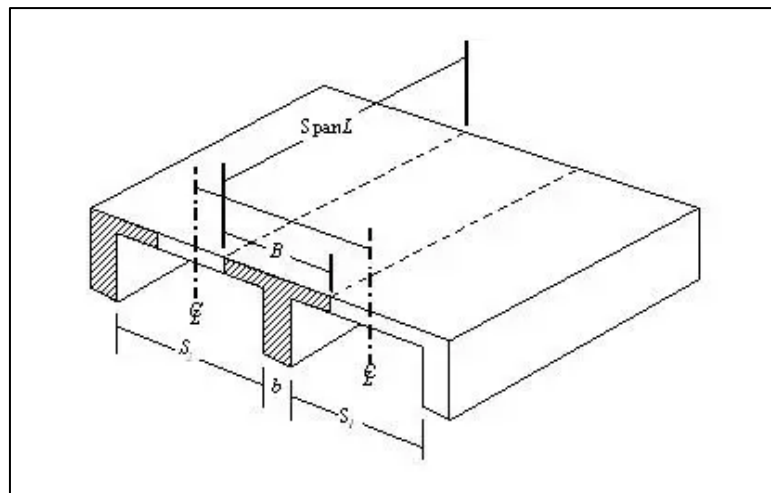


Fig. 7. Propose Monolithic Jointing for Beam and Slab (Gautam)

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