The Design of a Sport Stadium as a Design Experience to Final Year Students

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Abstract

The Integrated Design Project (IDP) is a hands-on, integrated discipline, design course introduced in 2008 to fourth year students at Civil Engineering Department in University Malaysia Sarawak (UNIMAS). The introduction of IDP is as a part of the department’s effort to fulfil the requirement of the Engineering Accreditation Council (EAC) where ‘exposure to engineering practice should be integrated throughout the curriculum and may be obtained partially through an industry-based final year project’. Several Civil Engineering subjects such as Project management, Geotechnical Engineering, Highway and Transportation Engineering, Water Resources and Water Supply Engineering, Environmental Engineering and Structural Engineering were integrated in this project. The design of a sports stadium was made the case study for the first IDP introduced. The students, working in groups, are required to produce a design solution taking into account the various civil engineering disciplines. Technical competencies are assessed from their reports and presentations, all of which are part of the IDP curriculum assessment. In this paper, the technical competencies with regards to the structural aspects of the sport stadium are considered. Students’ performance is assessed and discussed.

Keyword: integrated design project, design, final year student

1. Introduction

Integrated Design Project (IDP) is a compulsory course which needs to be taken by students in the fourth and final year of undergraduate study in the Civil Engineering Programme at Universiti Malaysia Sarawak (UNIMAS). This is a capstone design project which requires students to integrate the different fields of civil engineering for a given project and come up with a design solution at the end of the course. Students taking this course are divided into groups of 9 to 10 people and each student is assigned to a particular role in their respective groups. These roles include structural engineer, civil works engineer and project manager. The course has been designed in such a way that the experience is similar to what the student might expect in a real working environment in the design office.

Students are to complete this course in two successive semesters. In the first semester, students are required to come up with several design options and concentrate on the preliminary design of the project. This is the conceptual stage which takes into consideration not only the design issues but also the constructability and economical aspects. In the second semester, students will need perform their detailed design based on the ‘best’ option selected and produce a final design report.

In the 2008/2009 session, students were given the task to design a sports stadium. This stadium has a seating capacity of 300 people. The design consists of structural and civil works. In the structural design part, reinforced concrete and steel design are involved. As for the civil works, these include drainage and water reticulation system, road and traffic, geotechnical and foundation, and sewerage design. The project manager of each group is responsible to oversee the project as a whole and ensures the proper planning and coordination of the design works.

Half way through the course, a new set of client requirements were given to the students. It was decided that the proposed stadium needs to be large enough to cater for local major sporting events. Therefore, the seating capacity was increased to 1,000 people. However, the changes to the architectural plans of the ground floor layout are to be kept at a minimum. Students were required to use their ingenuity and creativity to design the stadium and make all necessary changes/improvements to satisfy these latest requirements.
In this paper, the proposed design and construction of the structural components of the sport stadium is the main topic of concerned. The steel design aspects looked into the proposed design and construction of the unique roof system of the stadium while the reinforced concrete design aspects were with the main building and its grandstand and the general spectators’ podium.

2. Course Plan and Assessment

In the conceptual design stage, the students are required to produce an inception report and a preliminary design report for the project. In the inception report of the project, students are required to propose several design options and look into the feasibilities of using various structural systems for the respective design options. From the proposed options, the students need to identify the ‘best’ option and develop this chosen option. The ‘best’ option must be substantiated with sound reasons. Apart from the design issues, constructability and economical aspects need to be considered in their options. In the preliminary design report, it was also expected that the students could approximately identify sizes of the structural elements to be designed for the different parts of the stadium.

The Final Design Report was to address the detailed design based on the ‘best’ option selected in a clear and orderly approach. Among the technical and design issues to be assessed includes the students’ ability to identify the limitations and address any constraints of the project, to know the Codes of practice, regulatory controls, standards, references, formulae used, to make out and discuss on the design considerations for the ‘best’ option. Design calculations and outcomes must be supported with relevant engineering drawings/sketches and convincing data. Clear construction procedures, practical design method and buildable options are among the constructability and buildability aspects evaluated in the report.

The assessment of the students’ ability during the conceptual and design stage of the sports stadium can be measured from the rubrics related to the ‘Technical and Design Aspects’ and the ‘Constructability and Buildability Aspects’ can be categorized under PO(d) and (k).

Table 1 Program Objectives (PO) for the Dept of Civil Engineering, Faculty of Engineering, UNIMAS

<table>
<thead>
<tr>
<th>PO</th>
<th>Description</th>
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<tr>
<td>(a)</td>
<td>ability to acquire and apply knowledge of science and civil engineering fundamental</td>
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<tr>
<td>(b)</td>
<td>acquiring in-depth technical competence in Civil Engineering discipline</td>
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<tr>
<td>(c)</td>
<td>ability to undertake problem identification, formulation and solution</td>
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<tr>
<td>(d)</td>
<td>ability to utilise systems approach to design and evaluate operational performance</td>
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<tr>
<td>(e)</td>
<td>understanding of the principles of sustainable development for engineering design</td>
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<tr>
<td>(f)</td>
<td>understanding and committed to the professional and ethical responsibilities</td>
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<tr>
<td>(g)</td>
<td>ability to communicate effectively with engineers and community at large</td>
</tr>
<tr>
<td>(h)</td>
<td>ability to function as a member or as a team leader at a multidisciplinary team</td>
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<tr>
<td>(i)</td>
<td>understanding of social, cultural, global and environmental responsibilities of a professional engineer</td>
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<tr>
<td>(j)</td>
<td>recognising the need to undertake life-long learning for individual capacity development</td>
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<tr>
<td>(k)</td>
<td>ability to use the techniques, skills and modern engineering tools necessary for engineering practice</td>
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In addition, indirect assessment of these two aspects was also made through a set of questionnaires given to students. This is used to gauge their personal experience upon completing the course.

3. Findings

3.1. Preliminary and Final Design Reports

From the students’ reports, it was observed that the students are able to propose several design options and make out the various structural systems for the respective options as seen in Figure 1 and 2 [1]. Considerations of the structural systems were based on the loads/load path to the foundation (i.e conceptual design), cost of the material, overall construction cost, methods of construction, durability and availability of material especially local materials, cost of labour and the construction timeline.
For the reinforced concrete structure which consists of the main building and the extended seating area, most of the options are either using precast concrete or cast-in-situ concrete for beams, columns and slabs. Most of the groups have decided to use the conventional cast-in-situ concrete since cost and availability of materials are thought as major determining factors. Critical areas under design and mostly highlighted in the report are the load transfer and design of the seating terrace for the main grandstand area as seen in Figure 3, 4 and 5[1]. All the groups’ design of the structural members is based on British Standard for reinforced concrete, BS8110:1985.

The steel structure mainly consists of the unique roof systems over the grandstand and the general spectators’ podium. Therefore, most of design considerations are regarding durability, availability and cost of materials, the structural system and feasible method of construction. Metal deck, tile roof and PVC membrane types are main options for roof material. Timber and steel trusses
are options for the roof trusses. For the roof structural systems, steel suspension cable roof, cantilevered truss, cantilevered portal frames and bracing systems are mostly being thought of by the students as feasible options as seen in Figure 6 and 7[1]. The designs of the structural members are based on British Standard for steel, BS5950:2000.

Fig. 6 Cantilevered truss system

![Cantilevered truss system](image)

Fig. 7 Membrane roof truss system

![Membrane roof truss system](image)

In this design project, it can be seen that the students obviously have gained a lot of exposure to understand the conceptual design of structures and to translate these into actual structural system as in Figure 6 and 7 [1]. For example, the students went to great depth on the design considerations for the steel and membrane roof truss system, such as the wind velocity consideration, uplift force consideration, eddy current consideration, turbulence flow consideration, connections, stability of the Arc membrane, construction of arc shape membrane, tuned mass damper, general buildability and constructability of the roof system.

3.2. Achievement of the Program Objectives (PO)

The passing percentage for the course serving as an indicator to PO achievement is marks of 60% of marks. With respect to the structural steel design, most of the groups scored more than 60% for the 'Technical and Design' aspects as shown in Figure 8 [1]. However, the 'Constructability and Buildability' aspects shows relatively lower passing percentages as seen in Figure 9 [1].

![Percentages of Technical and Design Aspects achieved](image)

Fig. 8 Percentages of Technical and design aspects achieved in Steel Design

![Percentages of Constructability and Buildability Aspects achieved](image)

Fig. 9 Percentages of Constructability and Buildability aspects achieved in Steel Design

With respect to the concrete design, most of the groups scored well above 60% for the 'Technical and Design' aspects as shown in Figure 10 [1]. However, the 'Constructability and Buildability' aspects shows relatively lower passing percentages as seen in Figure 11 [1].
3.3. Student Survey

Eighty-five respondents took part in the student survey. The followings are some of the many students’ feedbacks received from the students as regards to the design aspects and the IDP in general:

- “Real life of working experience! Structural design (drawing, calculation). Report preparation. Learn how to design”
- “Learn many beneficial and useful things in designing a structure. Know how to design the overall structural elements”
- “To design a real civil engineering project from the preliminary study state till the end of the design. I’ve learn that real civil engineering design works are NOT the same as what we learned in class…”
- “IDP good. But sometimes not good. Maybe because this is the first time. I manage to gain knowledge in dealing with client, design – any kind of design. Do not stop this course!”

4. Discussion and Conclusion

In general, all groups were able to come up with solutions or requirements of the project. The extent to how much more technical, elaborate or precise the groups can provide information in their reports explains the difference in their marks for both steel and concrete structural design.

Since the same project is given to all the groups, there is a great tendency between the groups to copy or share/split working between groups arising to reduction in marks due to plagiarism and/or non-original ideas. These were closely monitored by the examiners and if any groups found to copy off from one another, the group would be penalized through marks reduction. It was also found that one of the groups shows no clear idea of load transfer system.

The project to a great extent has made the students to become more proactive, creative and innovative not only in finding the design options but also learns to deduce solutions based on technical reasoning. Even though the IDP introduced encompass all aspects of civil and structural engineering design, particularly the conceptual and design aspects of the stadium building, the students indirectly developed greater competencies in the generic skills in report writing.

5. Recommendations

Based on the exit meeting after completing the course and students recommendation in the student survey, the number of students per group has been reduced to 5 to 6 students in the next IDP course.

6. Acknowledgement

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