Blended Design Approach of Long Span Structure and Malay Traditional Architecture

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Abstract: The growing population in the world is so fast, which is followed by the increasing need of some new and large activities. Architects face the problem on how to facilitate buildings with various activities such as for large meeting, conference, indoors gymnasium and sports, and many others. The long span structure of building is one of the solutions to solve that problem. Generally, large buildings which implemented this structure will look as a technological, modern and futuristic ones or even neo futuristic performance. But on the other hand, many people still want to enjoy the specific and unique senses of local traditional architecture. So is the Malay people who want an easy pleasant large facilities which can be fulfilled by implementing modern long span building structure technology. In the same time, their unique sense of Malay traditional architecture can still be maintained. To overcome this double problems of design, it needs a blended design approach of long span structure and Malay Traditional Architecture.

Keywords: blended design approach, long span structure, Malay traditional architecture.

1. Introduction

The growing population of Riau Province during recent decade is very fast. Based on the Statistics of Riau Province in 2016, Riau has 2.56% growth rate in 2014 - 2015. Besides this growth of people, Riau also becomes one of tourist destinations. Many seminars and conferences were held as part of MICE (Meeting, Incentive, Convention and Exhibition) activities in Riau. For example in 2012 Riau became the host of a national sport event (Pekan Olah Raga Nasional XIII) and National Sport for Difable Person XIV. With the high rate of population growth Riau tend to be a high density region. One of the consequence of that growth is the need of many new larger public facilities, such as terminal buildings, harbors, indoors sports and gymnasium buildings, stadions, tourism facilities and others. Such buildings refer to the structures of large scale building to cover an open clear space without any obstructions, which are called long span structures. Malay people in Riau Province have a great pride of their traditional architecture as they often perform it in their buildings, either private or public. The regional building regulation also ask the builder to implement traditional architecture as the component of the special building.

Architects have to do their design with an approach to both the long span structure and the Malay traditional architecture. This article will explore a four step design approaches. Firstly there will be a glance review to know the variations of structure of the large buildings in Riau Province which already exist. Secondly, a brief review of long span structure, and especially on shell structure and flat truss structure based on the reference from Heinrich Engel. Thirdly, a general review to the Riau Malay traditional architecture will be written based on the reference of Tenas Effendy. Fourthly, a brief concept of a blended design approach by choosing the structure system that is suitable with the need of performing Riau Malay traditional architecture. At the end of the article, it will show a 3D picture of an alternative pre-designs.
2. Blended Design Approach

Blended design approach is a process of designing by synthesizing two or more design aspects simultaneously to achieve the design goal. The building structure design approach done by architect is not exactly the same with what a civil engineer does. They do the same object, but with different goal and method. A civil engineer’s goal is to produce the whole system as well as the detail of building structure designed by calculating, drawing and even doing the tests. But the building structure they calculate was early designed by architects who estimated the structure system mostly by rule of thumb not by calculating it. Building structure design is always merely approached on the structural aspects, such as loads and moments mechanism, deflections, strength, durability etc. Whilst in this blended approach, the building structure will be analyzed by two aspects simultaneously, i.e. structural aspect and traditional architecture aspect. In a building with conventional structural approach, the traditional architecture is generally built as accessories, whilst in a blended approach the traditional architecture will be the structural element itself, so that it will occur as long as the building exist.

3. Large Buildings in Riau Province

As mentioned earlier, Riau Province has already had several large buildings as venues, which especially were constructed for facilitating the event of PON XIII in 2012. These buildings are mostly placed in Pekanbaru, but some of them are outside. This review will look at some of them which to be considered as representatives, they are main stadium, basketball hall, gymnasium hall and Youth Center (figure 1). In general all of these buildings are long span structure buildings. They are modern buildings which have interesting form and look as sporty huge performance. But none of them show a strong sense of Riau Malay traditional architecture, except a very small touch of accessory like a lipat kajang. When this accessory is uninstalled, the building will lose its sense of Riau Malay traditional architecture and looks like other buildings outside Riau Province. In order to become permanent identity, a traditional architecture should be a part of the building structure itself.

![Figure 1. Main Stadium, Gymnasium Hall, Youth Center and Basket Ball Hall.](image1)

The main stadium reinforces concrete in below structure and the roof structures are steel trusses which are placed in two directions so that it gives a vector active structure mechanism. While the other three buildings applied reinforce concrete as middle structures and space frame as roof structures. Gymnasium and basketball halls reinforce concrete structure as middle structure and space frame as roof structure. Youth Center reinforces concrete structure as middle structure and space frame as roof structure. The building has two masts tapered up to joint in its peak. The masts are accessories, not a structural mast. Another venue is the Unilak Student Center (Pusat Kegiatan Mahasiswa Unilak) in Rumbai. This building has a shell-like structure. Its roof is a spherical form which is very impressing combined with the line of steel main structure. In fact it is not a really shell structure, but space frame back bones as main structure combine with planar trusses to support the roof. Steel pipe columns stand along the periphery of the roof. But there is no identity of Malay traditional architecture at all, something that often be forgotten to place.

![Figure 2. Unilak Student Center in Rumbai Pekanbaru](image2)
The last monumental building in Pekanbaru is Regional Library of Riau Province (fig.2) this is not a building with specific traditional architecture of Malay Riau. No element which has a sense of Malay traditional architecture is found there. It is supported by reinforced concrete combine with steel as the middle structure and steel frame with metal sheet cladding as roof structure.

From the six buildings above, it can be concluded that it is rare to find of large buildings in Pekanbaru, Riau, which applies Riau Malay traditional architecture. When the traditional element is used such as lipat kajang, it is usually placed as an accessory in front of the main entrance of the building. But it only can be seen by people who come into the gate. It is not useful to give an identity of the whole building.

4. Long Span Structures

There are several terms of long span building which are made by individuals and institutions. In this article the term will be understood from Encyclopedia Britannica and American Institute of Architect (AIA). According to the Encyclopedia Britannica a long span building create an unobstructed, column-free spaces greater than 30M (100feet) for a variety of functions. These include activities where visibility is important for large audiences (auditorium and covered stadium), where flexibility is important (exhibition halls and certain types of manufacturing facility), and where large movable objects are housed (aircraft hangars). AIA didn’t define any specific definition of long span building. A 60 feet office building is considered as a long span, but not to a gymnasium. Whereas a 60 feet is a long span to timber structure, but not to steel structure.

To create a long span building, it can apply many types of structure. As the material of structure developed fast, the long span building is much easier to build. In this article, the long span structure pre-design will apply shell structure as main structure combined with flat truss structure as secondary structure. Sometimes a building applies a shell-like structure but actually it is not a real shell structure, which means that the building has a curve shape like a shell but the structure is not surface active structure system. The design approach of real shell structure in this case will be based on structure knowledge in Heinrich Engel’s book, Structure System. The shell structure concept here will cover 3 aspects, they are understanding shell structure as a surface active structure system, generating a geometrically defined basic shell shape of shell structure and developing the basic shell shape.

4.1 Shell Structure as Surface Active Structure System

Before talking about the concept of shell structure, it should review the relation of shell structure and surface active structure system. Surface active systems can be understood as structural surfaces which can be composed to form mechanisms that redirect forces. Structural continuity of the elements in two axes, i.e. surface resistance against compressive, tensile, and shear stresses are the first prerequisite and first distinction of surface active structure

The shell structure is one of the types of surface active systems, which will be developed in this article as a pre-design long span building, i.e. a harbor. The concept of this structure is to unite the logically and geometrically defined of long span structure with the artistic sense of Malay traditional architecture. It verify needs good consideration on choosing the type of structure. In designing a long span harbour, its important to create an unobstructed space to facilitate many people and vehicles with goods to be transported therein. The space also needs large openings, ventilation and natural lighting as well. Shell structure offers all of that is needed. This structure also has a clear interior performance and can be adjusted artistically. Later the concept of logically and geometrically defined will perform in pint 4.2 below.

4.2 Generating a Geometrically Defined Shape of Shell Structure

It is very important to generate a shell shape that geometrically defined. This form is to ensure that the builder can do the construction easier and without any difficulties that sometimes occur on a geometrically undefined shape. A geometrically defined shape is very important in a shell structure. A shape that is geometrically undefined in a shell structure will come to difficulties on its construction. Based on the book of Heinrich Engel, here will develop the generation of the basic shape. The generation is based on a rotate method with two main elements, i.e. a directrix and a generatrix (see fig. 4).
A straight line here as a generatrix will form the shape by rotating it along a directrix that is a half circle in a plane that lies at right angles to the generatrix. The action will form an envelope, half cylindrical shape, that’s a basic unit of shell shape. The shape is geometrically defined, because it has a defined radius of directrix, i.e. 4.0 meters. That will make the contractor's job easier.

4.3 Developing Basic Shell to a Larger Shape

The shell structure in this paper is designed to cover a large space, which needs several units of basic shell shape to be connected. As mention in Heinrich Engel’s book, there are several methods of juxtaposition for cylindrical surface connection. One of the methods which is applied here is a continuous connection (see fig 5). Another connection type that will be applied is transverse folding.

5. Riau Malay Tradisional Architecture

Traditional architecture is always an interesting object to be related with MICE and tourism. A harbor as a tourist gate of the region, must be designed with a special local tradition sense attract the guests’ attention who come through that gate. In this paper the harbor is designed with a Riau Malay tradional architecture component, that is singap or bidai layer (see figure 6). Singap is a layer to cover a front end of the roof, it is usually ornamented with carving timber. This ornament originally has a function as ventilation.
In the blended design here, bidai layer will be transformed to be a structural element with steel pipe material. It is impossible to use timber as structural material that will combine with fiber concrete shell material. The transformation form will change the ornament to a structural form of a vector active structure system. This system applies small trusses to be arranged as both structural and aesthetic. It is structurally elements which are dominated by triangles as stable form. It also still performs an aesthetic component of Riau Malay traditional architecture, even though it has been transformed (see figure 7).

![Figure 7. The transformed bidai layer](image)

### 6. The Design

The pre-design of harbor building structure will be based on the concept of blended long span structure and Riau Malay traditional architecture. The structural concept can be explained as follow.

a) The whole structure system is the combination of surface active structure system, i.e. shell structure and vector active structure system, i.e. planar trusses structure.

b) Shell structure as the first structural component consists of several basic units of cylindrical shape which are connected in juxtapose connection and folded connection methods.

c) Bidai layer is transformed to be the second structural element of triangle trusses that act as a vector active structure system.

The pre-design consists of plan, elevation and isometric (see figure 8, 9, 10 and 11). Because it is structural pre-design, so all of the figures are merely to show the building structure. There is no architectural space analysis and design.

![Figure 8. Plan](image)

![Figure 9. Side Elevation](image)
The building is a symmetrical form with structure that consists of shell structure and flat truss, it is stable to support vertical, horizontal and vibration loads. In the part of shell structure, there are five basic units that connected in juxtapose method at each side, let say right and left side. The two sides connected in folded method at the peak, while the shells are cut off in interval manner, as sky lights to allow a free orientation view to the sky. The shells are also folded at each side in interval manner, in order to form a Malay roof shape. Then in the part of flat truss, that consists of two huge flat trusses located at each end of the shell assemblage. The flat truss functions to stabilize the whole shell structure.

Finally, figure 11 shows the harbor building as a large building with a modern, futuristic and technological performance but still has the aesthetic of local traditional architecture of Malay Riau. The structure itself is simple with every part of the structures honest and easy to understand.

7. References

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