THE STRUCTURAL ANALYSIS OF KING PARAKRAMABAHU'S PALACE

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ABSTRACT

King Parakramabahu, (1153-1186) in Polonnaruwa monarch who built the 'ParakramaSamudra' had a magnificent seven storied palace called 'Vijayanta Prasada' or 'Vijayothpaya', the palace of God Sakra. This study has investigated the structural configuration of the palace through historical data and observation of existing part of the palace. The chronicles Chulawansa and Mahawansa has described the palace as seven storied building with thousand chambers. Though the main building possibly cannot hold such a number of chambers, when considering the whole palace complex this number seems a possible. The research was being conducted using the existing brick wall and was used to identify the column beam configuration and how the load path was distributed. The results revealed that the upper floors could have been made out of timber such as Weera and Palu and the existing wall must have held the massive wooden structure that form the floor of the upper level.

1. INTRODUCTION

Parakramabahu Palace, called VijayantaPrasada, is a magnificent seven-story structure which was built by King Parakramabahu, the great Polonnaruwa ruler who built the Parakrama Samudra. Although much of it is now in utter devastation, one can imagine how grand it once used to be. The remaining walls show grooves where timber columns with beams and wooden floors rose up like a step pyramid, reducing in area as with each floor.

Figure 1: It is assumed that large beams had been fitted to these huge grooves

The palace consists of one main wall surrounded by 40 interconnecting rooms. The palace and its courtyard are protected by walls, which were then encircled with another outer wall. Today, the massive walls over a meter thick going up to about 30 feet (9 meters) and also the bottom half of the main stairway which led to upper floors can only be seen as shown in Figure 2.

Figure 2: Existing parts of the palace. Circled section shows the remaining staircase for upper floors.

Large holes in the wall probably held massive wooden beams that formed the floor of the upper levels. Even after facing such destruction by human hand and then by Mother Nature for 800 years, the plastering on these walls still remains in some places.

The wooden columns and beams which are used

in upper floors are assumed to be made of ***Manilkarahexandra***(Palu) and Vera which have a considerable strength (about 40 MPa). An architect's impression of what it would have looked can be seen at the Polonnaruwa museum in a form of miniature model.

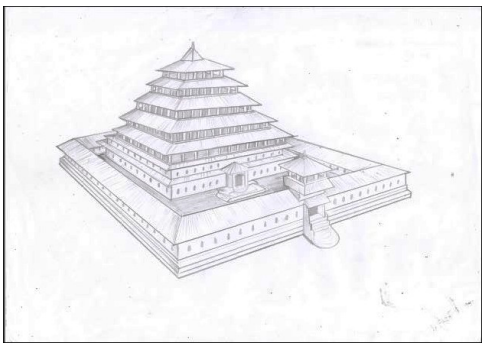


Figure 3: Schematic diagram of the miniature model at Polonnaruwa museum

2. METHODOLOGY

Structural Configurations

Based on the historical information in the Chula Wansa and MahaWansa and the field surveying on the existing part the palace, structural configuration of the palace is discussed in this study.

2.1 Column Layout

The remaining walls show some grooves like continuous vertical spaces which can be assumed as there were timber columns among those spaces to hold this massive structure. One column was about 10 meters in height. There were exactly 64 such grooves like spaces on the ground floor which can be taken as column. Distances between columns along the column line were measured as roughly 1.4 meters.

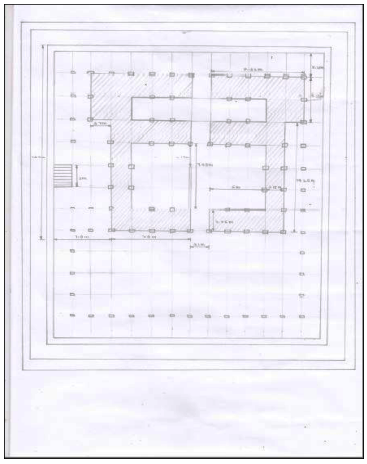


Figure 4: Column layout of the ground floor

2.2 Beam Layout

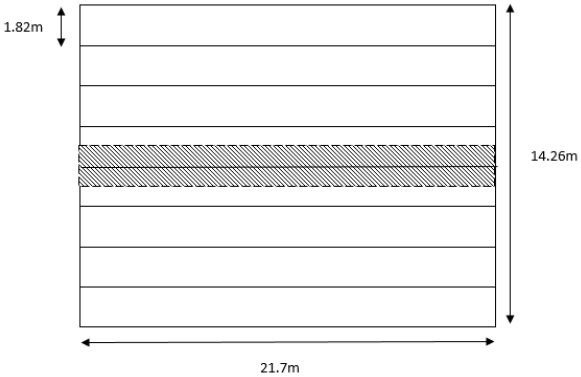
The voids in the main remaining walls suggested the size of the cross sections of main and cross beams which were the timber floor slab and there were about seven such larger voids for main beams and seven smaller voids for transvers beams in the perimeter of the wall. Based on that observation floor beam layouts were planned.

Figure 5: Grooves which hold cross beams.

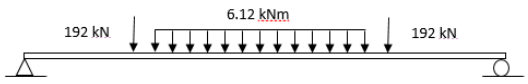
3. CALCULATION

Sample calculation for third floor:

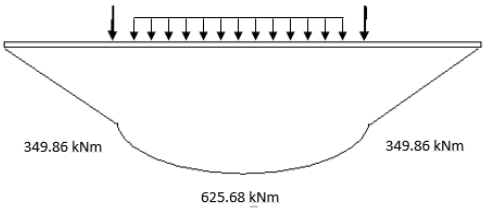
3.1 Beam layout



3.2 Beam



3.3 Bending moment diagram



Flexure formula

$$\frac{M}{I} = \frac{\sigma}{y} = E\phi$$

$$\sigma = \frac{My}{I}$$

$$\sigma_{allowable} = \frac{40 \times 10^3}{1.5}$$

$$I = \frac{1}{12} b^4$$

$$b = 520.21 \text{ mm}$$

Flexure formula is being used to find the beam size. The allowable stress of wood was found as 40 MPa and it was divided by a Factor of Safety of 1.5. The cross section of the beam was assumed as a square so that both width and the depth was taken as b. By using the theorem the depth was found as 520.21m.

Floor	Maximum B.M.(kNm)	Beam size(mm)
1st floor	625.68	520.21
2nd floor	625.68	520.21
3rd floor	625.68	520.21
4th floor	461.47	470.01
5th floor	322.78	417.22
6th floor	204.38	358.27

4. RESULTS

4.1 Load Path

Seventh floor is supported by 4 columns beneath it and the total load of the roof and the columns are resisted by the floor below it (sixth floor), likewise the total load below that floor is transferred to the columns below equally.

The load of the second floor is transferred to the first floor and then from the first floor through the columns to the ground.

The estimated width of a beam (size of existing voids) was approximately about 10 bricks (60 cm) although the calculated one differed from about 7cm (53 cm).

Floor	Theoretical dimensions(mm)	Experimental dimensions(mm)
1st floor	520.21	600.00
2nd floor	520.21	600.00
3rd floor	520.21	600.00

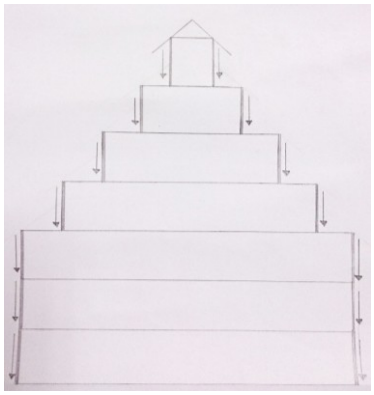


Figure 6: Load is transferred from seventh floor to the first floor through columns (Load path)

5. CONCLUSION

King Parakramabahu the great ruled Sri Lanka from 1153 to 1186. During his reign he had done excellent constructions and his palace is one of them. As the theoretical dimensions were nearly equal to the dimensions measured, it proves that our ancestors had a very good knowledge on theories of Structural Engineering even at those times. It is confirmed that they had used a theory similar to Euler-Bernoulli theorem.

6. REFERENCES

[1] Chula Vansa-

[2] Maha vansa-Kurunegala era

[3].Dhata vansaya