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Comparative Study of Quantity and Cost on Post Tensioned Slab and Reinforced Concrete Slab in Structures

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ABSTRACT

Nowadays the post-tensioning slab is increasing and widely used because of its architectural functions, flexibility in construction, the free design of space, and reduction of construction time. This paper is researched to compare the quantity and cost of sixteen storeyed reinforced concrete slab and post tensioned slab in buildings.. The analysis is done by ETABS software based on Uniform Building Code (UBC 97) for environmental loading and American Concrete Institute (ACI- 318-08) for consideration of design requirements for structural elements. The building is considered to be situated in earthquake zone 2B. Linear dynamic response spectrum analysis is used on the structures.

Keywords :— Post-tensioned slab, reinforced concrete slab, quantity, cost, ETABS

I. INTRODUCTION

The main structural action is one-way in such cases, in the direction normal to supports on two opposite edges of rectangular panel. In many cases, however, rectangular slabs are of such proportions and are supported in such a way that two-way action result. Types of reinforced concrete construction that are characterized by two-way action include slabs supported by walls, or beams on all sides, where the slab, or slab panel, is supported along its four edges by relatively deep, stiff, monolithic concrete beams or by steel girders.

Post-tensioned concrete floors form a large proportion of all prestressed concrete construction and are economically competitive with reinforced concrete slabs in most practical medium-to long span situations. Prestressing overcomes many of the disadvantages associated with reinforced concrete slabs. Deflection, which is almost always the governing design consideration, is better controlled in post-tension slabs.

Fig. 1 Reinforced concrete slab

Source [reference 4]

Fig2 Post-tension slab
Source [reference 4]

II. PROBLEM STATEMENT OF STUDY

In present work, the structure is modelled using ETABS software. Linear dynamic response spectrum analysis will be performed on the structures. In this paper, twenty-six design load combinations are used for superstructure of both structures. Load combinations are based on UBC 97 for environmental loading and ACI 318-08 for design of members. The size, material properties and loads of study structures are as follows.

A. Type, Size, Location and Height of Structure

- 16-storeyed reinforced concrete slab building and flat slab building with perimeter beams building
- Maximum dimension - 110 ft x 110 ft
- Location - Zone 2B
- Ground floor height - 12 ft
- Typical floor height - 10 ft

B. Material Properties

For selected models,

Material properties used for selected structure are:

(1) Design property data

- Concrete compressive strength, f'_c = 4 ksi
- Yield strength, f_y = 50 ksi
- Yield strength of tendon, f_y = 245.1 ksi

(2) Analysis property data

- Modulus of elasticity (concrete) = 3122 ksi
- Modulus of elasticity (rebar) = 29000 ksi
- Modulus of elasticity (tendon) = 28500 ksi
- Weight per unit volume (concrete) = 150 pcf
- Weight of unit volume (rebar & tendon) = 490 pcf
- Poisson's ratio (concrete) = 0.2
- Poisson's ratio (rebar & tendon) = 0.3
- Coefficient of Thermal expansion = 5.5×10^6

C. Loading considerations

Super imposed dead load,

- Dead load for floor = 20 psf
- Dead load for roof = 20 psf
- Dead load for stair = 20 psf
- Weight of elevator = 3 ton
- 41/2 in thick brick wall weight = 50 psf
- 9 in thick brick wall weight = 110 psf
- Dead load for brick wall (PT slab) = 50 psf

Live load,

- Live load for floor = 40 psf
- Live load for roof = 20 psf
- Live load for stair =100 psf

Wind load,

- Wind velocity = 120 mph
- Windward coefficient = 0.8
- Leeward coefficient =0.5
- Exposure type = C
- Important factor = 1

Earthquake load,

- Seismic zone = 2B
- Zone factor = 0.2
- Soil type = SD
- Response modification factor = 5.5
- Seismic coefficient, C_a = 0.28
- Seismic coefficient, C_v = 0.4
- Building period coefficient, C_t = 0.02
- Important factor = 1
- Damping ratio = 0.05

D. View of building

Corresponding columns size are the same for structures in Fig3, 4 and 5 respectively.

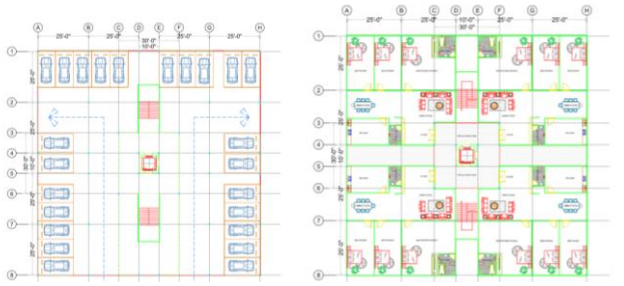

Fig3 Ground floor plan and typical floor plan

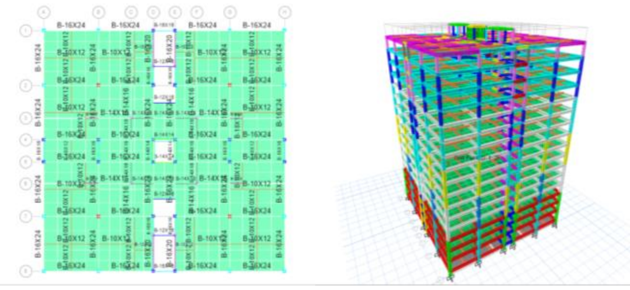

Fig4 Plan and 3D view of 6 in thick RC slab building

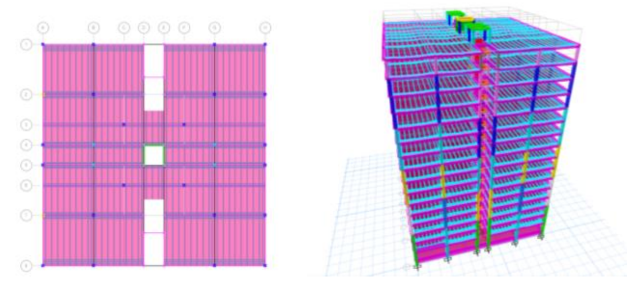

Fig5 Plan and 3D view of 10 in thick flat slab building

E. Determination of load combinations

Load combinations are based on ACI 318-08 for design and UBC-97 for environmental in both structures.

TABLE I

LOAD COMBINATION

No	For RC slab	For PT slab
1	1.4 D	1.4D + PT
2	1.2D + 1.6L	1.2D + 1.6L + PT
3	0.9D + 1.6WX	0.9D + 1.6WX + PT
4	0.9D – 1.6WX	0.9D – 1.6WX + PT
5	0.9D + 1.6WY	0.9D + 1.6WY + PT
6	0.9D – 1.6WY	0.9D – 1.6WY + PT
7	1.2D + L+ 1.6WX	1.2D + L+ 1.6WX+ PT
8	1.2D + L- 1.6WX	1.2D + L- 1.6WX+ PT
9	1.2D + L+ 1.6WY	1.2D + L+ 1.6WY+ PT
10	1.2D + L- 1.6WY	1.2D + L- 1.6WY+ PT
11	0.9D + EQX	0.9D + EQX + PT
12	0.9D - EQX	0.9D - EQX + PT
13	0.9D + EQY	0.9D + EQY + PT
14	0.9D - EQY	0.9D - EQY + PT
15	1.2D + L + EQX	1.2D + L +EQX + PT
16	1.2D + L - EQX	1.2D + L - EQX + PT

No	For RC slab	For PT slab
17	1.2D + L + EQY	1.2D + L+ EQY + PT
18	1.2D + L - EQY	1.2D + L - EQY + PT
19	0.9D + SPEC1	0.9D + SPEC1+ PT
20	0.9D - SPEC1	0.9D - SPEC1+ PT
21	0.9D + SPEC2	0.9D + SPEC2+ PT
22	0.9D - SPEC2	0.9D - SPEC2+ PT
23	1.2D + L + SPEC1	1.2D + L + SPEC1+ PT
24	1.2D + L - SPEC1	1.2D + L - SPEC1+ PT
25	1.2D + L + SPEC2	1.2D + L + SPEC2+ PT
26	1.2D + L - SPEC2	1.2D + L - SPEC2+ PT

Where,

- D = dead load
- L = live load
- WX = wind load in x direction
- WY = wind load in y direction
- EQX = earthquake load in x direction
- EQY = earthquake load in y direction
- PT = post tension load
- SPEC1 = dynamic load in x direction
- SPEC2 = dynamic load in y direction

III. RESULT AND DISCUSSION

In the present study, we calculate the cost of the structure based on steel's price 438.48 USD per ton and concrete's price 55.63 USD per m^3 respectively.

A. Quantity of steel comparison

As per estimated result based on ETABS, we found that the quantity of steel in PT slab structure is 16.01% less than in RC slab structures which are shown in Figure 6 and 7. In this steel quantity comparison, we use the same material however, excluded for tendon consideration.

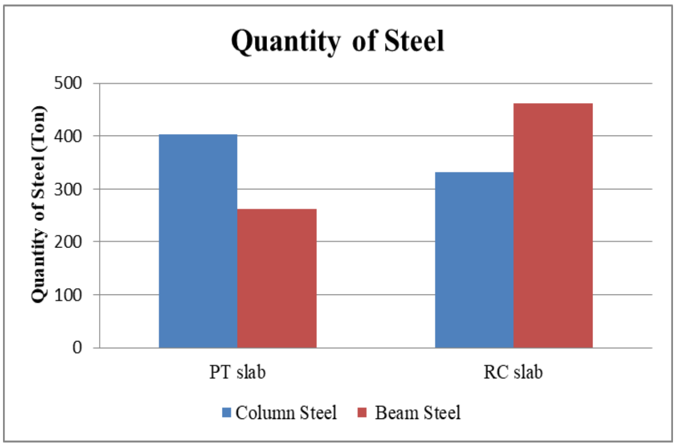

Fig6 Quantity of steel in PT and RC slab structures for columns and beams

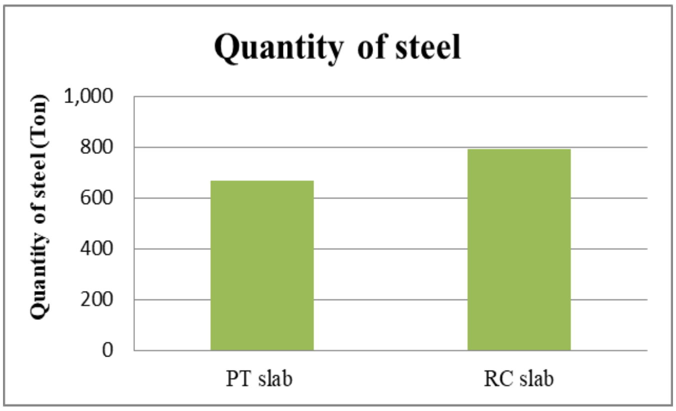

Fig7 Overall quantity of steel in PT and RC slab structures

B. Cost of steel comparison

During the research study, we observe that the cost of steel in PT slab building is less than 16.01% than RC slab building. The analysis is based on the same material but not including tendon. The research result is shown in Figure 8 and 9.

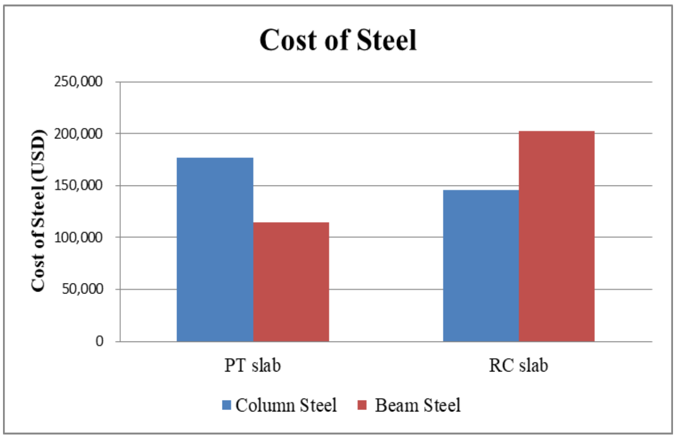

Fig8 Cost of steel in PT and RC slab structures for columns and beams

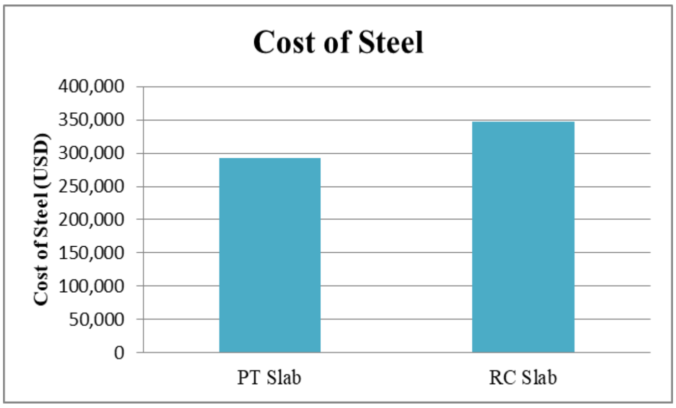

Fig9 Overall cost of steel in PT and RC slab structures

C. Quantity of concrete comparison

Due to think slab requirements, the quantity of concrete in PT slab structure is significantly greater (32.41%) than in RC slab structure as illustrated below in Figure 10 and 11.

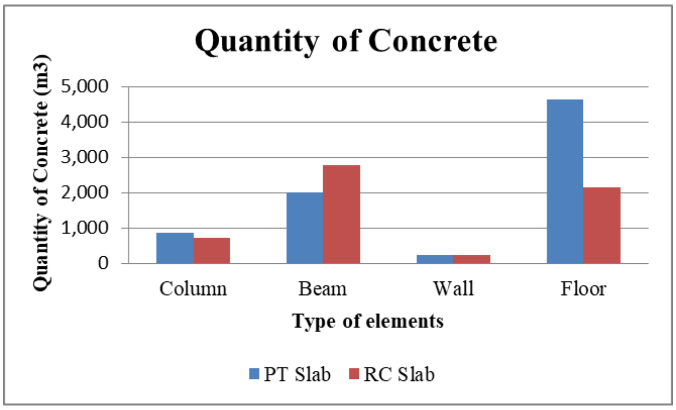

Fig10 Quantity of concrete in PT and RC slab structures for column, beam, wall and floor

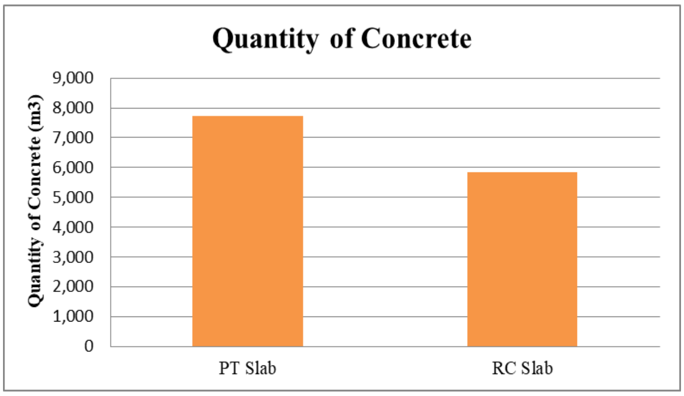

Fig11 Overall concrete quantity in PT and RC slab structures

D. Cost of concrete comparison

The cost of concrete in PT slab structure is 32.41% greater than in RC slab structure in Figure 12 and 13.

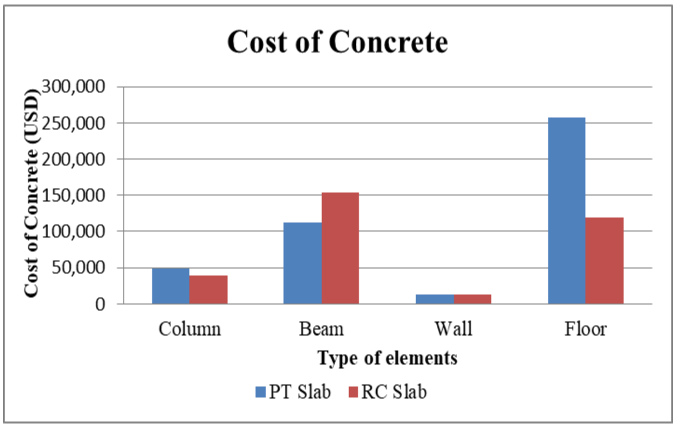

Fig12 Cost of concrete in PT and RC slab structures for column, beam, wall and floor

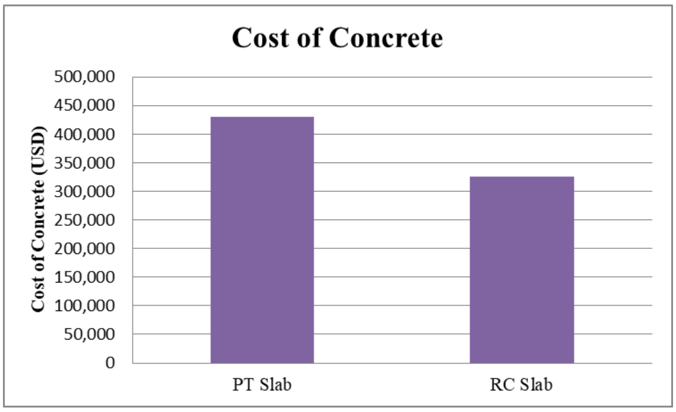

Fig13 Overall cost of concrete in PT and RC slab structures

E. Total Cost comparison

In this study, Figure 14 indicates the comparison of total cost of the structures which PT slab structure is 7.39% more expensive than RC slab structure.

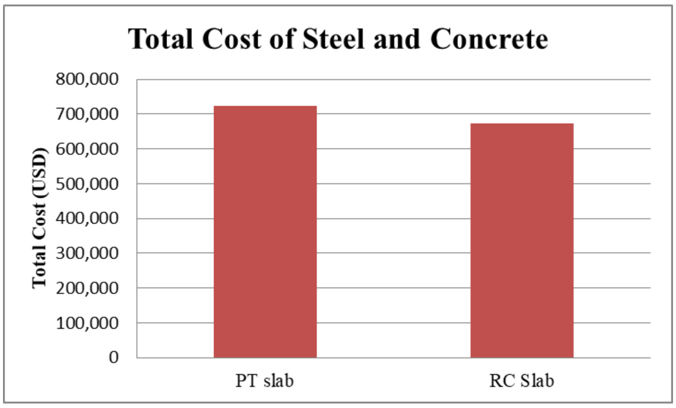

Fig14 Total cost comparison in PT and RC slab structures

IV. CONCLUSIONS

The comparative study of RC and PT slab structure is presented. The parameters considered in this research are quantity and cost of beams, columns, and slab. Thus, based on the analysis the following conclusions are drawn.

- The quantity and cost of steel in PT structure is less 16.01% than RC structure. The cost of column steel in PT slab building is higher than RC slab building but also the cost of beam steel in PT slab structure is less than the RC slab structure according to Figure 8 and 9.
- The quantity and cost of concrete in PT slab structure is 32.41% greater than RC slab structure. The volume of concrete in beams, columns in RC and PT slab structures are slightly different but the volume of concrete of floor is significantly different as show in Figure 10.
- The total cost of PT slab structure is increased by 7.39% compared to the RC slab structure.
- The PT slab buildings are more popular according to the point of architectural view, the free design of space and reduction of construction time but their costs are more expensive than the RC slab buildings.

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