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Conference Paper

Analysis of the Relationship of Concrete Column Structural Elements to Steel Frame Beams Supporting Swimming Pool Loads in the East Coast Center II Phase 2 Surabaya Project

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ABSTRACT

The swimming pool is located on the top floor of the building with a large swimming pool making structural design pay attention to all aspects, especially safety aspects when used. The structural method used in this study is a combination of structures between concrete columns and Bailey model steel frame beams. The use of steel frame beams is because the swimming pool has an area of 27 m x 20,5 m and under the swimming pool there should be no columns to create a spacious room. In the combination of these structures, the relationship between concrete columns and steel frame beams (JCB) is connected using anchors as a component that transfers loads. The anchor used is an L-shaped anchor model. The anchor is connected at four end points of the steel frame beam which helps transfer the load to the concrete column. From the results of the analysis with ETABS software, the largest value of the axial force (Fz) is 5525113,22 N and the shear force (Fx) is 6438725 N. According to SNI 2847: 2019, the anchor needed to reduce the axial force and shear force is used 52 36 mm diameter anchors with a shear capacity value of 6496089,6 N and an axial capacity value of 12492480 N.

Keywords: Anchor, JCB, axial force, shear force

Introduction

The construction of swimming pools on top of buildings (pool decks) is rampant in line with the development of modern development. With the swimming pool located above the building, the swimming pool structure must include various important elements designed to support the function and safety of the swimming pool (Istiono & Khoe, 2021). Additional load in the form of pool water is a significant additional load on the building structure. In planning the swimming pool structure above the building, reinforced concrete structure is usually used as the main structure.

In the East Coast Center II phase 2 project there is a swimming pool on the 15th floor with a swimming pool area of 27 m x 20.5 m. In the project planning, the swimming pool is used as a hall which requires a fairly large area without a column in the middle of the room. With these challenges in mind, this research used a combination of a steel frame beam structure spanning 27 m supported by 2 reinforced concrete columns, chosen to support the overall load of the swimming pool, considering the size of the swimming pool. So structural planning replaces the role of reinforced concrete beam structures with steel frame beam structures as a solution to this problem.

As a connection between the concrete column structure and the steel frame beam (JCB), an anchor is used to stabilize the motion of the structure when receiving axial loads, earthquake

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loads, and wind loads. Anchor is a steel element that is embedded in concrete before it is cast into concrete or installed after the concrete has hardened. Anchors are used to connect different structural components between concrete structures and steel structures in the hope that the two components can transfer energy to each other due to loads. Loads that may act on the anchor are tensile forces, shear forces, a combination of tensile and shear forces, and bending moments (Keras et al., 2021). The shape of the anchor varies from L, U, J, and straight shapes and has a diameter that varies according to the load it will bear.

Material and Methods

This research was conducted by taking a case in the East Coast Center II Phase 2 building construction project in Surabaya. The location of this building is near the north coast of Surabaya which makes the building receive a large enough wind load. Based on SNI 1726: 2019 soil testing that has been carried out, the soil has an SE soil site classification (soft soil) (Zachari & Turuallo, 2020). The data used in this research is secondary data where the data includes the location of the anchor planting, anchor details, and structural plans. For the loading plan, the dead load and live load are used as a centralized load on the steel frame beam. Meanwhile, the earthquake load is adjusted to the calcification of the soil site class in the building construction area and likewise for the wind load adjusted to the building construction area with SNI 1272: 2020 regulations.

The data management method is carried out in stages, namely the planning of frame beams, loading on frame beams, and analyzing the relationship between concrete columns and frame beams. In planning using ETABS software, pinch fixation is used in the relationship between the truss beam and the concrete column (JCB). JCB analysis is carried out after obtaining the values of shear force, axial force, and moment due to the planned load (Wang et al., 2023). The analysis aims to review the number of anchors and anchor dimensions needed and determine the capacity value of the anchor group. There are 4 anchor group planting points on the frame beam that function to distribute the load to the concrete column. Calculation of anchor strength capacity analysis is carried out at each point of the anchor group in accordance with SNI 2847: 2019 concerning structural concrete requirements for building buildings (Hafid, 2019).

Anchor strength analysis

Determine base plate dimensions

The dimensions of the base plate or base plate are plate sheets with certain dimensions and thicknesses that connect the anchor with the steel frame beam. In determining the dimensions of the base plate, it is known that the maximum nominal stress value (f_{pmax}) must be greater than the nominal plan stress (f_p). To determine f_p, the axial force value obtained from analysis with ETABS software is needed.

$$fpmax = \Phi c \times 0{,}85 \times f'c \quad (1)$$

$$fp = Fz/(B \times N) \quad (2)$$

Available,

$$fpmax > fp$$

Determining the minimum spacing of anchors

In determining the spacing distance between anchors in order to prevent structural failure in the breaking of the anchor and tearing of the base plate. Determination of anchor spacing also creates maximum anchor group strength in structural strength. Anchor spacing is determined based on the dimensions of the anchor used (da). Determination of anchor spacing according to regulations, namely SNI 2847: 2019 article 17.7.2.

$$\text{Minimum anchor distance from anchor axle to anchor axle} = 2{,}5 \times da \quad (3)$$

Minimum anchor distance from anchor axle to column edge = 75 mm
Minimum anchor distance from the anchor axle to the edge of the base plate = 1,75 x da (4)

Control anchor strength capacity against tensile

The anchor is tensile controlled to determine the strength of the anchor when receiving a tensile force. The tensile force (Fz) value is obtained from the analysis using ETABS software. The value of the anchor capacity is the value per anchor which is then multiplied by the number of anchors needed to meet the requirement to be greater than the tensile force (Fz). Determination of anchor strength against tensile according to SNI 2847: 2019 article 17.4.1.2 regulations.

$$\Phi.Nsa = \Phi \times Asen \times Futa \quad (5)$$
$$Asen = \pi/4 \; \times (Da - 0{,}9743/Nt)^{\wedge}2 \quad (6)$$

Available,
$Fz < n \times \Phi.Nsa$

Tensile state anchor pull-out strength capacity control

In the control of the tensile state anchor pull-out strength is a control of the failure of the anchor embedded in the concrete. This prevents the release of the anchor that has been embedded in the concrete. to determine the capacity of the anchor to the tensile strength according to the regulations of SNI 2847: 2019 article 17.4.3.

$$Npn = \psi c{,}P \times Np \quad (7)$$
$$Np = 0{,}9 \times f'c \times eh \times da \quad (8)$$
$$\Phi Npn = \Phi \times \psi c{,}P \times Np \quad (9)$$

Available,
$Fz < n \times \Phi.Npn$

Control of anchor capacity against shear

The review of the anchor against shear aims to determine the capacity of the anchor against shear force (Fx). The shear force (Fx) value is obtained from the analysis using ETABS software. The capacity value of the anchor is reviewed as the value of one anchor which is then multiplied by the number of anchors needed to meet the requirement that the value must be greater than the shear force. To determine the capacity of the anchor against the shear strength of the anchor according to SNI 2847: 2019 article 17.5.1.2.

$$\Phi.Vsa = \Phi \times 0{,}6 \times Asev \times Futa \quad (10)$$
$$Asen = \pi/4 \; \times (Da - 0{,}9743/Nt)^{\wedge}2 \quad (11)$$

Available,
$Fx < n \times \Phi.Vsa$

Results and Discussion

Analysis of the relationship between concrete columns and steel frame beams

In the relationship between concrete columns and steel frame beams are connected using anchors and base plates. To determine the number of anchors, anchor diameter and base plate thickness requires several forces in the ETABS software output. The required output is the shear force (F_x), axial force (F_z), and moment.

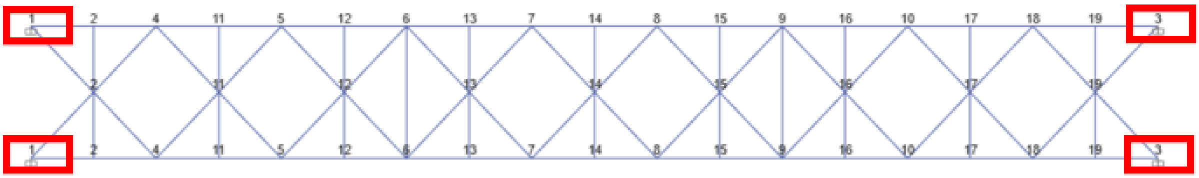


Figure 1. Join the number of bailey model truss beams

Table 1. Force at the join of frame beam with concrete column

Number of Join	Fx (N)	Fz (N)	Mx (N.mm)
1 (Top)	1181139	5525113,22	371721178
1 (Under)	6212253,5	1929690	32321424923
3 (Top)	1810461	5508097,46	400148840
3 (Under)	6438725	1911095	35559113369

In Table 1. are the values of shear force (Fx), tensile force (Fz) and moment (Mx) due to loads obtained from analysis using ETABS software. These values are the force values of the 4 anchor group points that connect the frame beam to the concrete column. From the force and moment values, the join is then controlled against the capacity to determine the number of anchors needed.

Determine base plate dimensions

To plan the dimensions of the base plate or base plate, some material data information is needed. This research uses concrete with a quality of f'c 40 Mpa. The dimensions of the base plate planned in this study are cube-shaped with a size of 900 mm x 1000 mm.

fpmax = Φc x 0,85 x f'c
= 0,65 x 0.85 x 40 = 22,1 Mpa

$f_p = \frac{Fz}{B\ x\ N}$

$= \frac{5525113.22}{900\ x\ 1000} = 1,91$ Mpa

f_{pmax} > f_p

22,1 Mpa > 1,91 Mpa **(OK)**

Determining the minimum spacing of anchors (SNI 2847: 2019 article 17.7.2)

To determine the anchor distance, the diameter of the anchor used is required. In this study the anchor is planned to use a diameter (da) of 36 mm.

- For minimum anchor spacing from anchor to anchor axle
  Minimum anchor spacing = 2,5 x da
  = 2,5 x 36 = 90 mm
- For minimum anchor spacing from anchor axle to column edge
  Minimum anchor spacing = 75 mm (Cast and permanently)
- Minimum anchor distance from the anchor axle to the edge of the base plate
  Minimum anchor spacing = 1,75 x da
  = 1,75 x 36 = 63 mm

Control anchor strength capacity against tensile (SNI 2847: 2019 article 17.4.1.2)

In the control of anchor capacity against tensile, the largest tensile force (Fz) value is taken as a reference, namely at join number 1 (top) of 5525113.22 N.

$A_{sen} = \frac{\pi}{4}\ x\ \left(Da - \frac{0{,}9743}{Nt}\right)^2$ nt (number of threads) = 0,24 (Table 3 ACI 318-14)

$= \frac{\pi}{4}\ x\ \left(36 - \frac{0{,}9743}{0{,}24}\right)^2$

$= 800{,}8\ mm^2$

$\Phi.N_{sa} = \Phi \text{ x } A_{sen} \text{ x } F_{uta}$

$= 0{,}75 \text{ x } 800{,}8 \text{ x } 400$

= 240240 N/angkur

$F_z < n \text{ x } \Phi.N_{sa}$ n = number of anchors

5525113.22 N < 52 x 240240

5525113.22 N < 12492480 N **(OK)**

Tensile state anchor pull-out strength capacity control (SNI 2847: 2019 article 17.4.3)

In the control of anchor capacity against the tensile strength of the anchor, the largest tensile force (Fz) value is taken as a reference, namely at join number 1 (top) of 5525113.22 N.

$N_{pn} = \psi_{c,P} \text{ x } N_p$ $\psi_{c,P} = 1{,}4$

$N_p = 0{,}9 \text{ x } f'c \text{ x } eh \text{ x } d_a$ eh = 120 mm (length of anchor hook)

= 0,9 x 40 x 120 x 36

= 155520 N

$\Phi N_{pn} = \Phi \text{ x } \psi_{c,P} \text{ x } N_p$

= 0,7 x 1,4 x 155520

= 152409,9 N

$F_z < n \text{ x } \Phi.N_{pn}$ n = number of anchors

5525113.22 N < 52 x 152409,9

5525113.22 N < 7925314,8 N **(OK)**

Control of anchor capacity against shear (SNI 2847: 2019 article 17.5.1.2)

In the control of anchor capacity against shear, the largest tensile force (Fx) value is taken as a reference, namely at join number 1 (top) of 6438725 N.

$A_{sen} = \frac{\pi}{4}\ x\ \left(Da - \frac{0{,}9743}{Nt}\right)^2$ nt (number of threads) = 0,24 (table 3 ACI 318-14)

$= \frac{\pi}{4}\ x\ \left(36 - \frac{0{,}9743}{0{,}24}\right)^2$

$= 800{,}8\ mm^2$

$\Phi.V_{sa} = \Phi \text{ x } 0{,}6 \text{ x } A_{sev} \text{ x } F_{uta}$

= 0,65 x 0,6 x 800,8 x 400

= 124924,8 N/angkur

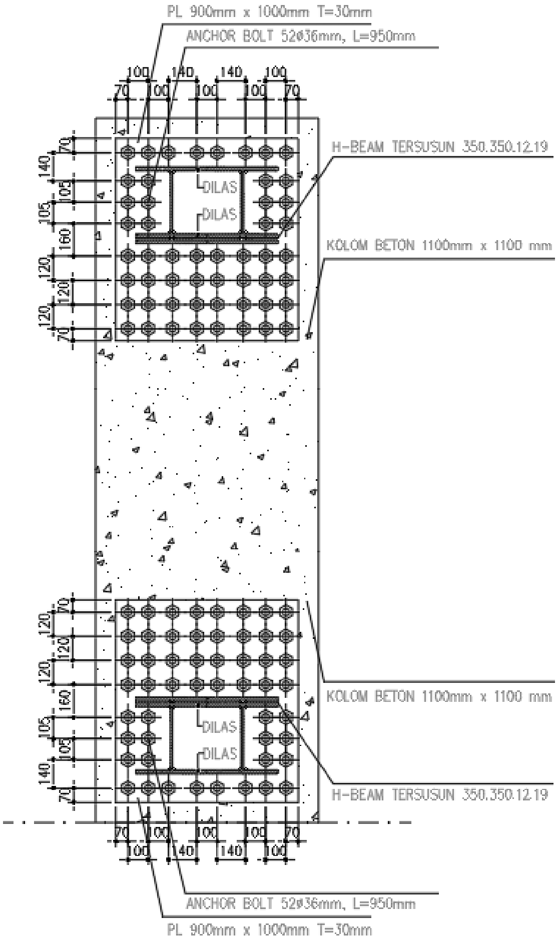
$F_x < n \text{ x } \Phi.V_{sa}$ n = number of anchors

6438725 N < 52 x 124924,8

6438725 N < 6496089,6 N **(OK)**

From the results of the anchor capacity control against tensile and shear, the results show that to reduce the shear force (Fx) and tensile force (Fz), 52 anchors with a diameter of 36 mm are used. The number of anchors is for each point of the anchor group where there are 4 anchor group planting points in the frame beam structure. The required length of anchor embedded in concrete is 800,8 mm.

In Figure 2. is the position of the group location whose distance arrangement is in accordance with SNI 2847 regulations: 2019 article 17.7.2. The base plate used in planning the connection of



frame beams with concrete columns is 900 mm x 1000 mm. The minimum anchor distance from axle to axle is 90 mm, while the minimum anchor distance to the edge of the column is 75 mm, and the minimum distance from the anchor to the edge of the base plate is 63 mm.

Figure 2. Position of frame beam anchors against concrete columns

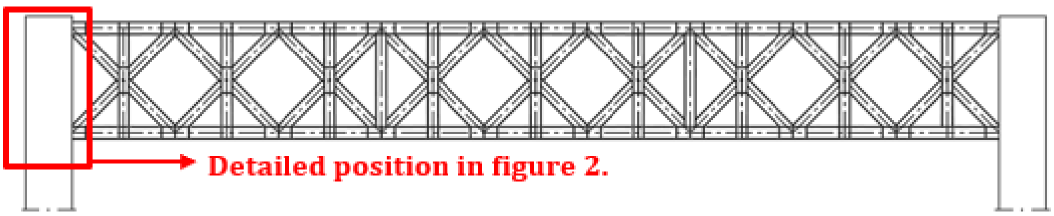


Figure 3. Side view of steel frame beams

Conclusion

The relationship between the frame beam and the concrete column is connected to 4 anchor points. The analysis value of the largest value obtained is for the shear force (Fx) 6438725 N and the axial force (Fz) 5525113.22 N. From these results for the anchor against the axial force, 52 36 mm diameter anchors are needed with an anchor capacity value of 12492480 N, and against the shear force 52 36 mm diameter anchors are needed with an anchor capacity value of 6496089.6 N. The base plate used measuring 900 mm x 1000 mm can reduce the force reaction caused by the planned load. The anchor embedded in concrete has a minimum length of 800.8 mm. Thus, the relationship between concrete columns and steel frame beams connected using anchors embedded in concrete columns meets the requirements according to SNI 2847: 2019 article 17.4.

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