DESIGN AND STRUCTURAL ANALYSIS OF A PRECAST INDUSTRIAL BUILDING

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Keywords

Precast concrete, Industrial building, Structural analysis, Sap2000.

Abstract

This study examines the design and structural analysis of a precast reinforced concrete industrial building composed of three halls. The building includes a partial second floor located in the upper left section of the plan, where the story heights are 438 and 440 cm respectively. The structural system consists of precast columns and beams, roof purlins, trusses, gutter elements, and the connection details that link these components. The use of a precast system is preferred in industrial construction because it shortens production and installation time, reduces overall cost, and significantly minimizes on site operations. The structural analysis was carried out with the Sap2000 program, and dead, live, snow, wind, and seismic loads were modeled in accordance with the relevant national standards. The design process followed the requirements of TS 498, TS EN 1991-1-3, TS EN 1991-1-4, Specification for the Design, Calculation and Construction of Steel Structures-2016, and the Turkish Building Earthquake Code 2018. The behavior of the building was evaluated using a linear elastic analysis approach, and the resulting displacements, internal forces, and connection forces remained within code limits. An increase in stiffness was observed in the region containing the second floor, and this condition contributed positively to the overall stability of the structure. The findings indicate that the building provides a balanced load carrying capacity under both vertical and horizontal actions, demonstrating that precast reinforced concrete systems offer a reliable and economically advantageous solution for industrial facilities.

PREFABRİK DÖKÜM ENDÜSTRİYEL BİNANIN TASARIMI VE YAPISAL ANALİZİ

Anahtar Kelimeler

Prefabrik beton, Endüstriyel yapı, Yapısal analiz, Sap2000.

Öz

Bu çalışma, üç bölümden oluşan bir prefabrik betonarme endüstriyel binanın tasarım ve yapısal analizini incelemektedir. Bina, planın sol üst kısmında yer alan ve kat yükseklikleri sırasıyla 438 ve 440 cm olan kısmi bir ikinci kat içermektedir. Yapısal sistem, prefabrik kolonlar ve kirişler, çatı aşıkları, kafes kirişler, oluk elemanları ve bu bileşenleri birbirine bağlayan bağlantı detaylarından oluşmaktadır. Prefabrik sistemin kullanımı, üretim ve montaj süresini kısaltması, toplam maliyeti düşürmesi ve şantiye operasyonlarını önemli ölçüde azaltması nedeniyle endüstriyel inşaatlarda tercih edilmektedir. Yapısal analiz Sap2000 programı ile gerçekleştirilmiş ve ölü, canlı, kar, rüzgar ve sismik yükler ilgili ulusal standartlara uygun olarak modellenmiştir. Tasarım süreci TS 498, TS EN 1991-1-3, TS EN 1991-1-4, Çelik Yapıların Tasarımı, Hesaplanması ve İnşası için Şartname-2016 ve Türkiye Yapı Deprem Yönetmeliği 2018 gerekliliklerine uygun olarak gerçekleştirilmiştir. Binanın davranışı doğrusal elastik analiz yaklaşımı kullanılarak değerlendirilmiş ve elde edilen yer değiştirmeler, iç kuvvetler ve bağlantı kuvvetleri kod sınırları içinde kalmıştır. İkinci katın bulunduğu bölgede sertlik artışı gözlemlenmiş ve bu durum yapının genel stabilitesine olumlu katkı sağlamıştır. Bulgular, binanın hem dikey hem de yatay etkiler altında dengeli bir yük taşıma kapasitesi sağladığını göstermekte ve prefabrik betonarme sistemlerin endüstriyel tesisler için güvenilir ve ekonomik açıdan avantajlı bir çözüm sunduğunu ortaya koymaktadır.

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1. Introduction

Precast industrial buildings are constructed with structural elements manufactured in a controlled factory environment and assembled on site. These systems are widely preferred in industrial zones because they shorten production and installation time, allow construction costs to be managed effectively, and enable large spans to be achieved with ease. They present an efficient solution for facilities that require wide and column free production areas such as workshops, warehouses, and manufacturing halls. Factory production improves material quality and significantly reduces workmanship related errors that may occur on site. As a result, the overall construction period becomes shorter and the environmental impact during construction is minimized. With the recent rise in industrial investments in Türkiye and the growing demand for rapid construction, the use of precast reinforced concrete systems has become increasingly common. Their durability, economic advantages, and sustainable characteristics have made them one of the primary structural options for industrial buildings (Çankaya, 2020; Karakuş & Yıldırım, 2021; Öztürk & Akıncı, 2018; Saraç & Şenol, 2019; Yalçınkaya & Doğan, 2017).

The major advantage of precast systems is the high level of quality control during the production stage, since the elements are manufactured under standardized factory conditions. This ensures reliable material quality and minimizes the potential for construction errors. However, the long term safety and performance of precast buildings depend directly on accurate engineering analysis and appropriate design decisions. In industrial facilities, it is essential to model the structural behavior under seismic effects with precision, to represent the behavior of connection regions realistically, and to design load transfer mechanisms correctly. In countries such as Türkiye, where seismic activity is a critical factor, these buildings must not only remain standing but must also continue to support industrial operations without interruption after an earthquake. For this reason, the design of precast industrial structures requires a rigorous engineering approach that considers load carrying capacity, seismic safety, and operational continuity.

Precast reinforced concrete solutions, which are widely used in industrial buildings throughout the country, have also gained a dedicated section within the TBEC 2018 (Disaster and Emergency Management Presidency, 2018). In addition to the loads defined in TS 498 (Turkish Standards Institute, 1987), snow and wind loads are addressed in TS EN 1991-1-3 (Turkish Standards Institute, 2007) and TS EN 1991-1-4 (Turkish Standards Institute, 2007), providing a more comprehensive framework for evaluating structural actions. The building is designed in accordance with the requirements of the Turkish standard TS 500 (Turkish Standards Institute, 2000).

Studies on the analysis of precast industrial buildings remain limited compared with other structural systems. This is primarily due to the complex behavior of connection regions and the challenges associated with modeling them accurately. Furthermore, the presence of variable spans and changes in stiffness throughout the structure complicates analytical modeling. As a result, existing research has generally focused on specific connection details, seismic behavior, or global stiffness characteristics of precast systems. The number of studies that examine the structural performance of precast industrial buildings is limited, and the available research approaches the subject through different modeling techniques, analysis methods, and material assumptions.

Elsanadedy and colleagues investigated the behavior of precast concrete beam to column connections strengthened with steel plates using nonlinear finite element analysis and demonstrated that these strengthening measures can prevent collapse when a column is removed (Elsanadedy, Al-Salloum, Alrubaidi, Almusallam, & Abbas, 2021). Huang and his team proposed a new beam to column connection type based on an ideal plastic hinge mechanism and showed through Abaqus analyses that the system performs better than monolithic connections in terms of strength, stiffness, deformation capacity, and energy dissipation (Huang, Hu, Miao, & Fan, 2021). Ghayeb et al. examined the behavior of precast beam to column connections under seismic and impact loads, providing a detailed assessment of ductility, energy consumption, and plastic hinge formation. Belleri focused on displacement based design for precast frames and demonstrated through nonlinear time history analysis how connection behavior influences global deformation capacity (Ghayeb, Abdul Razak, & Ramli Sulong, 2020).

Kataoka and colleagues conducted a finite element investigation of slab to beam to column connections and validated their models with experimental data, enabling a detailed assessment of stress and deformation patterns in precast joints (Kataoka, Ferreira, & Cresce El, 2017). Ravasini et al. developed a simplified modeling approach to evaluate sudden column removal scenarios in precast systems and demonstrated its engineering applicability through nonlinear time history analyses on a three-story building (Ravasini, Belletti, Brunesi, Nascimbene, & Parisi, 2021). Wan and his team proposed a connection element formulation for modeling precast concrete diaphragms in two-dimensional finite element analyses and evaluated diaphragm stiffness, strength, and deformation capacity through nonlinear pushover analysis (Wan, Zhang, Fleischman, & Naito, 2015). Quiel et al. developed a new beam to column connection detail designed to prevent collapse after ground floor column loss in ten story precast frame structures and showed that the proposed detail preserves structural integrity under nonlinear dynamic loading (Quiel, Naito, & Fallon, 2019). Debs et al. investigated semi rigid precast connections through experimental testing and analytical modeling and reported significant improvements in stiffness and displacement performance when compared with hinged or fully rigid systems (El Debs, Miotto, & El Debs, 2010).

Wang et al. developed innovative precast concrete shear walls for modular high rise buildings and showed through finite element analyses of a forty-story example in Hong Kong that the system performs effectively under wind and seismic actions (Wang, Pan, & Zhang, 2020). Nastri and his team examined the behavior of a strengthened traditional precast industrial building and demonstrated that their strengthening technique increases the ductility capacity significantly based on incremental dynamic and pushover analyses (Nastri, Vergato, & Latour, 2017). Girgin conducted experimental studies on composite precast beam to column joints under reversed cyclic loading and used calibrated numerical models to investigate the effects of bond deterioration and reinforcement deformation in connection regions (Girgin, 2014).

Guaygua et al. conducted a comprehensive review on the seismic performance of precast concrete buildings, highlighting the lack of research in this field and emphasizing the need for more studies on large span industrial systems (Guaygua, Sánchez-Garrido, & Yepes, 2023). Zhao and Takahashi examined the seismic behavior of prestressed precast concrete frames with relocated hinge connections and showed that the proposed system reduces residual drift and improves self centering capacity (Zhao & Takahashi, 2024). Ostetto et al. evaluated the effectiveness of strengthening strategies in precast industrial buildings and reported improvements in ductility and energy dissipation (Ostetto, Bianchi, Ruggieri, & Romano, 2022). Tang et al. investigated beam to column joints strengthened with U shaped ultra high performance concrete shells, and reported that these details exhibit strength, stiffness, and energy dissipation levels close to those of monolithic connections (Tang, Chen, Wu, & Zhang, 2021).

In this study, the structural analysis of a precast reinforced concrete industrial building consisting of three halls is carried out in accordance with the relevant design codes. The analyses consider dead, live, snow, wind, and seismic loads, and the structural behavior is evaluated in Sap2000 using a linear elastic approach (Computers and Structures Inc., 1996). Unlike many previous studies, this work not only examines the structural system but also evaluates modal characteristics, soil structure interaction, and foundation behavior in detail. The dynamic properties of the building, including natural vibration periods and mode shapes, are identified, and the influence of soil structure interaction on displacements and stress distribution is assessed. The results show that the structural elements remain within code limits in terms of displacement, sectional capacity, and connection forces. The foundation system also satisfies allowable soil pressure limits. Overall, the study demonstrates that precast reinforced concrete systems offer safe and economical solutions under both static and dynamic loads. Future studies may focus on nonlinear behavior and experimental investigation of connection regions to better understand the post earthquake.

2. Materials and Method

2.1. Structural Model

The structure examined in this study is a precast reinforced concrete industrial building located in an industrial region in Türkiye and composed of three halls. In the upper left part of the plan, there is a partial two-story section with story heights of 438 c and 440 cm. Each hall has its own structural system, and the halls are separated by expansion joints. The foundation system is a mixed arrangement that includes both isolated and continuous footings. All analyses and calculations were carried out using the SAP2000 program. The three-dimensional model of the building is presented in Figure 1.

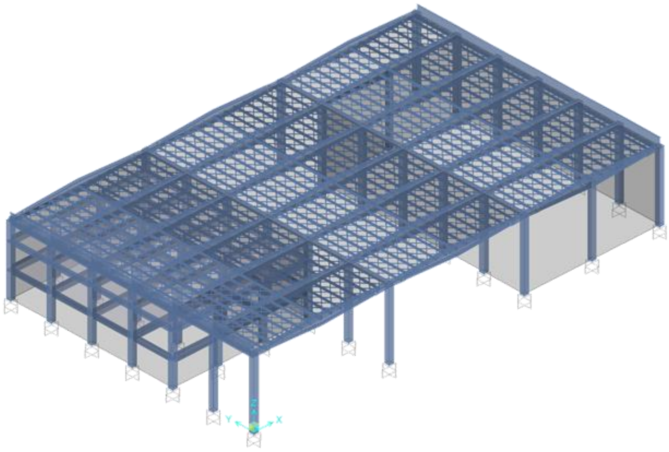

Figure 1. Structural model

The structural elements of the building, including columns, beams, purlins, gutters, and trusses, were designed as precast components. In the three-story portion, the intermediate floors are connected through moment resisting frame beams, while the truss and gutter connections at the tops of the columns are modeled with pinned end conditions. Different values of the structural behavior factor and the overstrength factor were assigned to the lower and upper levels of the building, allowing the seismic response at each story to be evaluated with greater accuracy. The plans of the various sections of the structure are presented in Figure 2.

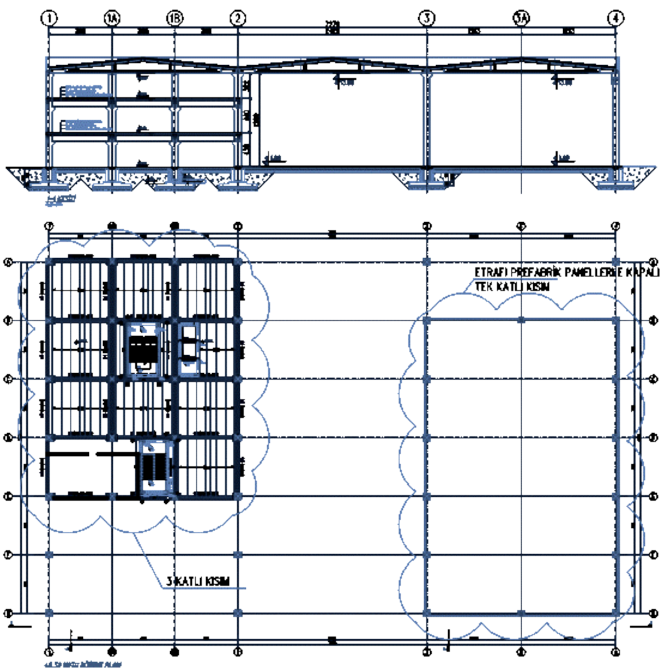

Figure 2. Plan views

Concrete class C35 was used for the columns, while C30 concrete was used for the gutter elements and the foundations. Reinforcement steel was selected as grade B420C, and the steel profiles were chosen as S235 for tubular sections and S275 for IPE sections. All analyses were conducted in accordance with TS 498, TS EN 1991-1-3, TS EN 1991-1-4, the Specification for the Design, Calculation and Construction of Steel Structures 2016, and the Turkish Building Earthquake Code 2018. Load combinations were established based on the requirements defined in these standards.

2.2. Method

In this study, the behavior of the structural system of the precast reinforced concrete industrial building was examined in a comprehensive manner under various loading conditions. The analyses were carried out using the SAP2000 finite element program. The stiffness properties of the precast elements were assigned to represent the behavior of the connection regions accurately. A linear elastic analysis approach was adopted, and dead load, live load, wind, snow, and seismic loads were defined separately. The structural responses were then evaluated under the appropriate combinations established in accordance with the relevant standards.

The load combinations used in the analysis were determined based on the standards. These combinations included both vertical and horizontal actions. Seismic loads were calculated by incorporating the vertical component as defined in Section 5 of the Turkish Building Earthquake Code. The study provides a comparative assessment of the effects of different loading conditions on the system, with particular emphasis on the global stiffness and stability of the structure under seismic loading. The findings highlight the importance of considering the design and analysis processes of precast reinforced concrete industrial buildings in an integrated and holistic manner.

3. Load Effects

The structural analysis of the building was carried out to evaluate the behavior of the load carrying elements under various loading conditions in a comprehensive manner. The self-weight of the structure was automatically considered by the program, while slab, roof, cladding, snow, wind, and seismic loads were applied to the elements in accordance with the provisions of the relevant standards. Slab loads were defined for the multi-story precast section. To represent the actual behavior of the precast system more accurately, dead loads were introduced in two stages.

The first stage of dead loads represents the condition before the cast in place reinforced concrete columns and beams reach their final strength, referred to as G_1. The second stage, defined as G_2, corresponds to the condition after the concrete has completed its curing. The hollow core slab load BD20 with a value of 280 kg/m2 and the 10 cm topping layer with a load of 250 kg/m2 were assigned as G_1, while a cladding load of 100 kg/m2 was assigned as G_2. This approach is particularly important for capturing possible changes in stress distribution and variations in load transfer in the connection regions. The bending moment diagrams obtained from these two loading stages are presented in Figure 3. The live load was applied as 500 kg/m2.

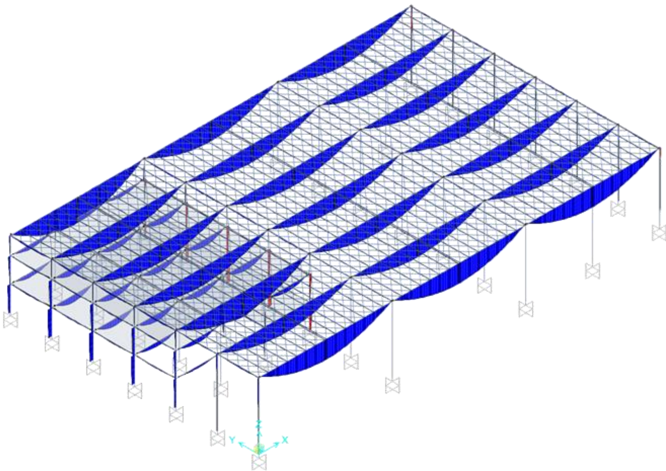

Figure 3. Moment diagram corresponding to the $G_1 + G_2$ load combination

For the single-story portion of the structure, the calculated loads were applied as roof loads. The total roof load was determined as 40 kg/m2, consisting of a roof cladding load of 15 kg/m2 and a roof solar panel load of 25 kg/m2. For the precast facade panels, a facade cladding load of 250 kg/m2 was applied. The color scale representing the cladding and facade loads is presented in Figure 4.

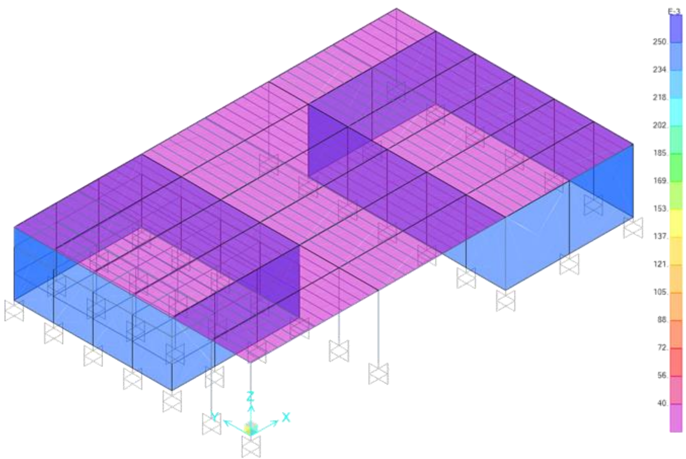

Figure 4. Cladding and facade loads

The snow load was determined as 75 kg/m2 based on the provisions of TS 498 and by considering the elevation of the building above sea level. The wind load values acting on the vertical walls and the roof were calculated according to the wind direction, and the results are presented in Figure 5.

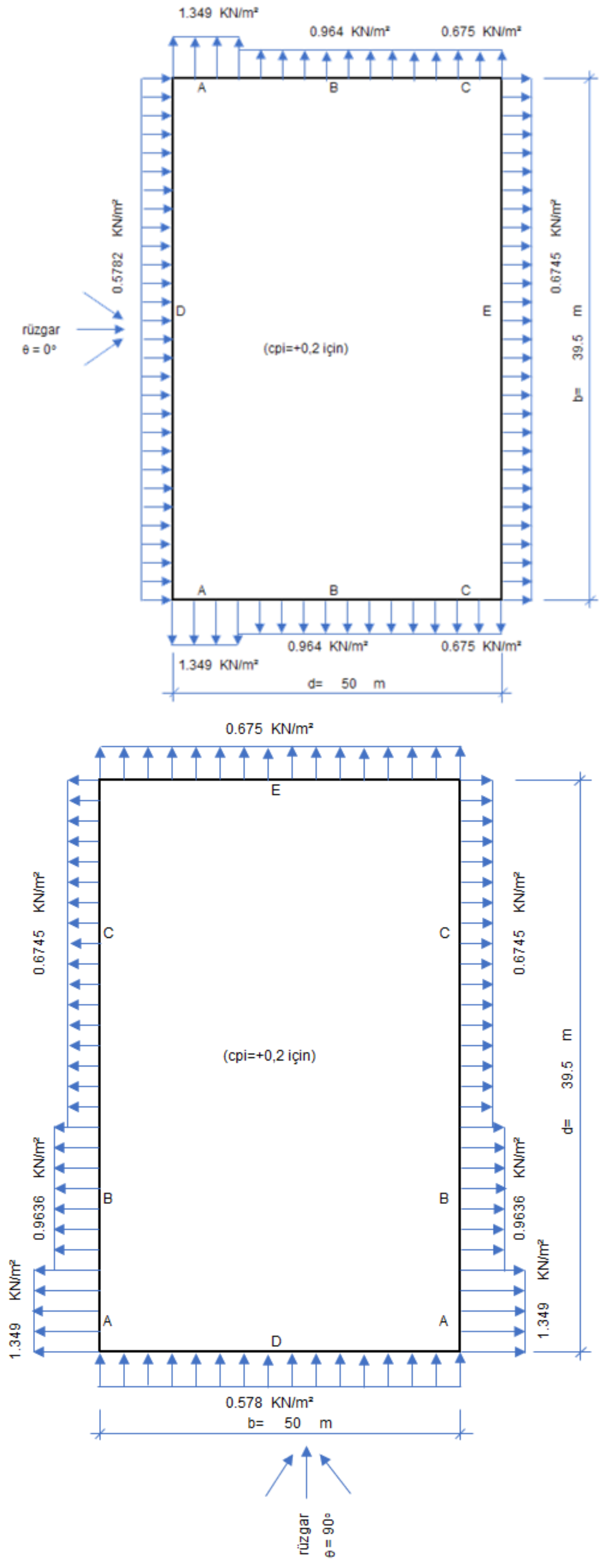

Figure 5. Wind loads

The structure is located on a site classified as local soil class ZD, consisting of medium dense to dense sand, gravel, or very stiff clay layers. Using the Turkish Earthquake Hazard Map, the peak ground acceleration for the DD2 earthquake level, which corresponds to a ten percent probability of exceedance in 50 years, was obtained as 0.41 g, and the peak ground velocity was determined as 24.32 cm/s. The participation factor for live loads was taken as thirty percent of the snow load at the roof level. Based on these considerations, the effective building weight used in the seismic analysis was calculated as 3625.7 t. The modal analysis indicated that the fundamental periods of vibration were Tx = 1.096 sec in one direction and Ty = 0.496 sec in the other direction, as shown in Figure 6. The empirical natural vibration period defined in TBEC-2018 is given in Equation 1. The coefficient Ct is specified as 0.1 for reinforced concrete structural systems. Accordingly, the empirical period was calculated as TpA = 0.1 × 0.1x123/4 = 0.64 sec. The code requires that the period used in the analysis must not exceed 1.4 TpA, which corresponds to 0.90 seconds. For this reason, the period values used in the calculations were limited to 0.90 sec.

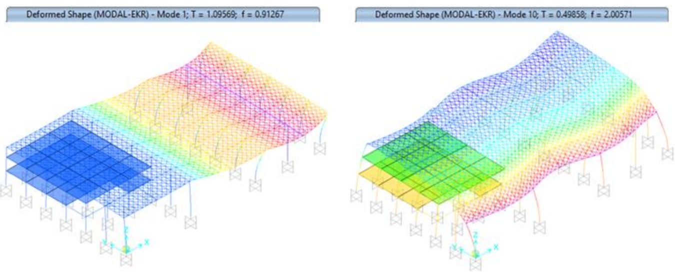

Figure 6. Natural vibration periods

$$T_{pA} = C_t H_N^{3/4} \quad (1)$$

Due to the irregular distribution of mass participation ratios in the building, the modal combination procedure was used together with the linear analysis method. Effective stiffness modifiers of 0.35 for beams and 0.70 for columns were assigned. In accordance with TBEC 2018, the structural behavior factor and the overstrength factor for the upper portion of the structure, where the column tops are modeled with pinned end conditions, were taken as 3 and 2 respectively. As specified in Article 4.3.6 of TBEC 2018, the values of the structural behavior factor and the overstrength factor for the lower portion were recalculated by considering the base shear forces. Based on the calculations performed using Equations (2) and (3), the structural behavior factor and the overstrength factor for the lower portion were obtained as 3.85 and 1.75 in the x direction, and 4.34 and 2.07 in the y direction.

$$(\bar{R}_a)_{alt} = \frac{(R_a)_{üst}}{V^{(X)}} \quad (2)$$

$$\bar{D}_{alt}^{(X)} = \frac{0.6V_{üst}^{(X)} D_{üst} + V_{alt}^{(X)} D_{alt}}{V^{(X)}} \quad (3)$$

The displacements obtained in each direction from the analysis were extracted from the program, and the corresponding story drift values were calculated. These values were then compared with the permissible limits defined in TBEC-2018. For each seismic direction, the maximum story drift at every story level must satisfy the condition given in Equation (4). In this equation, the coefficient κ is taken as 1 for reinforced concrete buildings. The coefficient λ represents the ratio of the elastic design spectral acceleration values calculated for the DD3 and DD2 seismic hazard levels. This coefficient was obtained as 0.446. The results of the story drift check are presented in Tables 1 and 2.

$$\lambda = \frac{\delta_{i,max}^{(X)}}{h_i} 0.008\kappa \quad (4)$$

Table 1. Story drift check in x direction

Story	Height (cm)	Displacement (cm)	δi (cm)	Check
Multi-story Section				
2	322	9.21	3.95	0.0054<0.008
1	440	5.26	3.11	0.0031<0.008
Z	448	2.15	2.15	0.0021<0.008
Single-story Section				
Story	Height (cm)	Displacement (cm)	δi (cm)	Check
2	1200	21.5	21.5	0.00796<0.008

Table 2. Story drift check in y direction

Story	Height (cm)	Displacement (cm)	δi (cm)	Check
Multi-story Section				
2	322	5.30	1.60	0.0022<0.008
1	440	3.70	2.20	0.0022<0.008
Z	448	1.50	1.50	0.0015<0.008
Single-story Section				
Story	Height (cm)	Displacement (cm)	δi (cm)	Check
2	1200	14.66	14.66	0.0054<0.008

4. Analysis of Structural Elements

The building includes columns with cross sectional dimensions of 60 by 60 cm, 70 by 70 cm, and 80 by 80 cm. After determining the required longitudinal reinforcement areas for the columns, the load carrying capacity ratios were evaluated. The maximum required transverse reinforcement was calculated as 0.302 cm2/cm. To satisfy this requirement, four leg stirrups with a diameter of 10 mm spaced at 10 cm were used, providing a transverse reinforcement ratio of Asw/s = 4 × 0.785 ÷ 10 = 0.314 cm2/cm. As an example, the reinforcement detailing of an 80 by 80 cm column located in the multi-story section is shown in Figure 7.

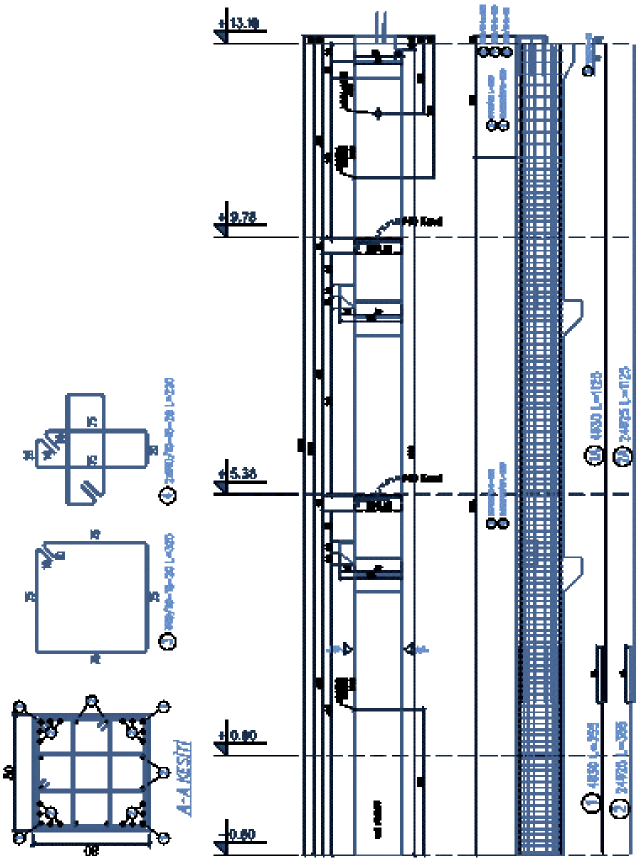

Figure 7. Column reinforcement details

The beams in the load carrying system have cross sectional dimensions of 30 by 60 cm, 30 by 70 cm, and 40 by 80 cm. In accordance with TBEC-2018, the requirement stating that the sum of the flexural capacities of the columns framing into a joint must be at least %20 greater than the sum of the flexural capacities of the beams at the column face was applied. The control performed for the most critical case is presented in Figure 8 and Table 3.

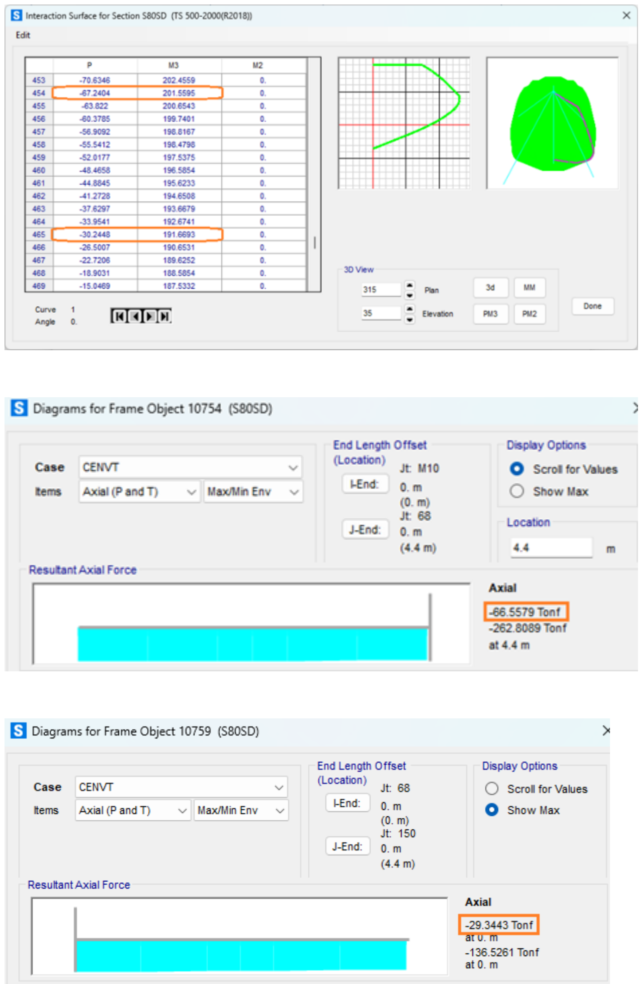

Figure 8. Column internal forces

Table 3. Story drift check in y direction

Kolon	Ndü, Nda (t)	Mra, Mrü (tm)	Mra+Mrü (tm)
S80x80	29.3 66.6	191.6 201.5	393.1
Mri, Mrj (tm)	1.2(Mri+Mrj) (tm)	Kontrol	
143.6 126.2	323.8	393.1>323.8	

5. Soil Analysis

The site is classified as soil class ZD, with a subgrade modulus of 1400 t/m3 and an allowable bearing capacity of 25 t/m2. Maximum soil pressure checks for both single and continuous foundations were carried out for various load combinations, and the results are presented in Table 4. The maximum soil pressure obtained under the G+Q+E load combination, which includes the effect of seismic loading, is shown in Figure 9.

Table 4. Soil stress values

Foundation type	Load combination	Maximum soil stress (t/m^2)
Single footing	G+Q	11.0 < 25.0 ✓
Continuous foundation	G+Q	12.3 < 25.0 ✓
Single footing	1.4G+1.6Q	15.7 < 25.0 ✓
Continuous foundation	1.4G+1.6Q	17.6 < 25.0 ✓
Single footing	G+Q+E	24.5 < 25.0 ✓
Continuous foundation	G+Q+E	24.8 < 25.0 ✓

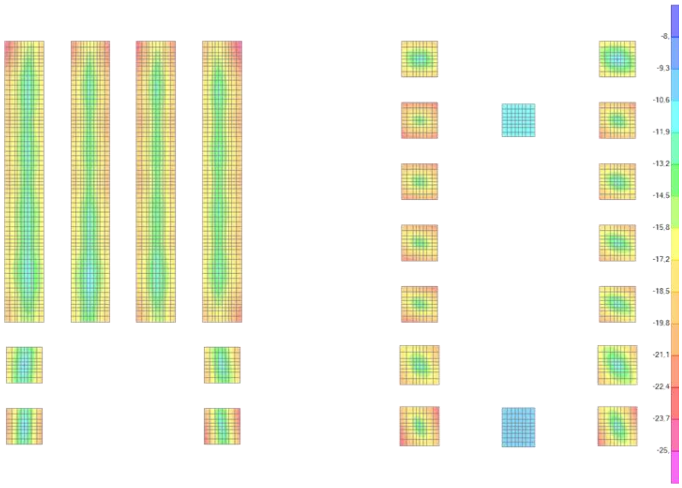

Figure 9. Maximum soil stress for the seismic load case

6. Foundation Calculations

The width, length, and thickness values of the single footings used in the structure are presented in Table 5. A concrete cover of 5 cm was applied in all isolated footings. For each footing, the internal forces were calculated, and the reinforcement design was completed. A minimum reinforcement ratio of 0.002 was adopted in the calculations.

Table 5. Properties of the single footings

Footing name	BxHxD (cm)	Minimum reinforcement (cm^2/m)	Selected reinforcement (cm^2/m)
T1	480x480x50	0.002x480x45 = 43.2	25ø16/20 = 50.3
T2	440x440x50	0.002x440x45 = 39.6	23ø16/20 = 46.2
T3	400x400x50	0.002x400x45 = 36.0	21ø16/20 = 42.2

For the T1 isolated footing, which has the largest cross-sectional dimensions among the foundations, the maximum bending moment distribution in both directions (M11, M22) is presented in Figure 10. The plan view and the reinforcement detailing of Section 1–1 are given in Figure 11.

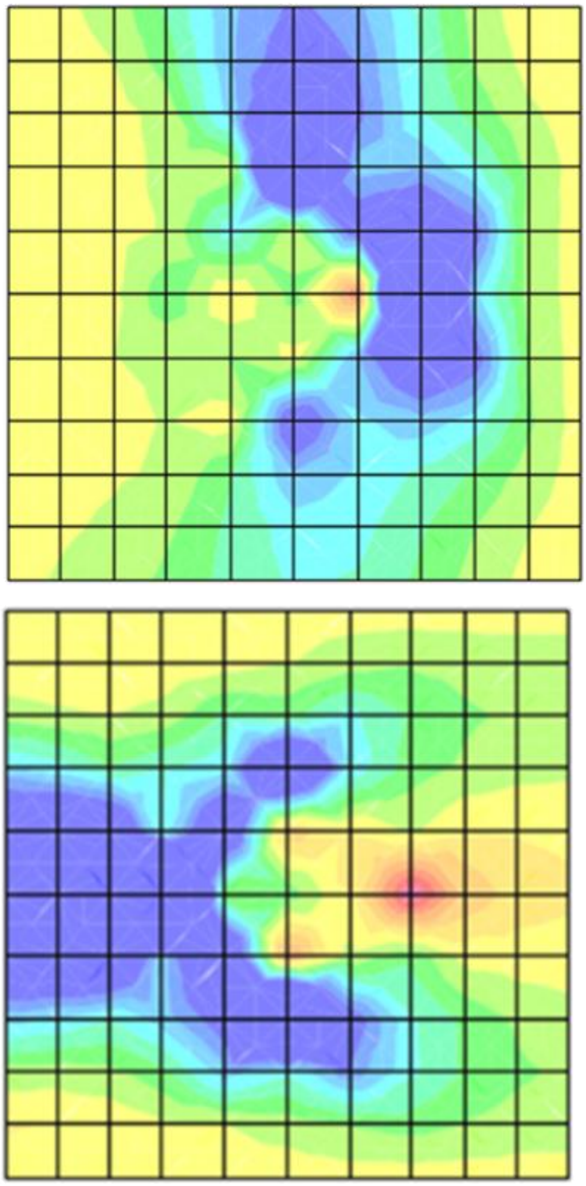

Figure 10. Maximum moment distributions

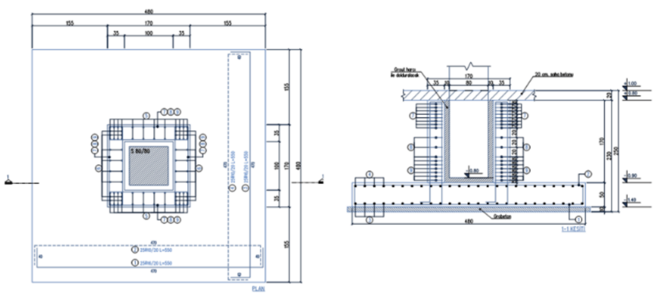

Figure 11. Reinforcement details

Four different continuous foundation beams were used in the structure. The properties of the continuous foundations are presented in Table 6. In addition, the foundation layout plan, which shows the dimensions and naming of the continuous foundations, is given in Figure 12.

Table 6. Properties of the continuous foundations

Foundation name	BxHxD (cm)	Minimum reinforcement (cm^2)	Selected reinforcement (cm^2)
T4	230x480x70	0.002x230x65 = 29.9	12ø18/20 = 30.5
T5	230x480x70	0.002x230x65 = 29.9	12ø18/20 = 30.5
T6	230x480x70	0.002x230x65 = 29.9	12ø18/20 = 30.5
T7	230x480x70	0.002x230x65 = 29.9	12ø18/20 = 30.5

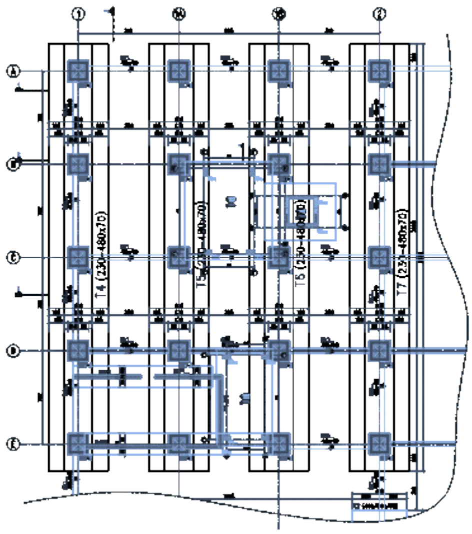

Figure 12. Details of the continuous foundation

The reinforcement selected for the continuous foundation beam consists of 12ø18 bars placed continuously along the entire length of the beam. The details of the foundation beam cross section are presented in Figure 13.

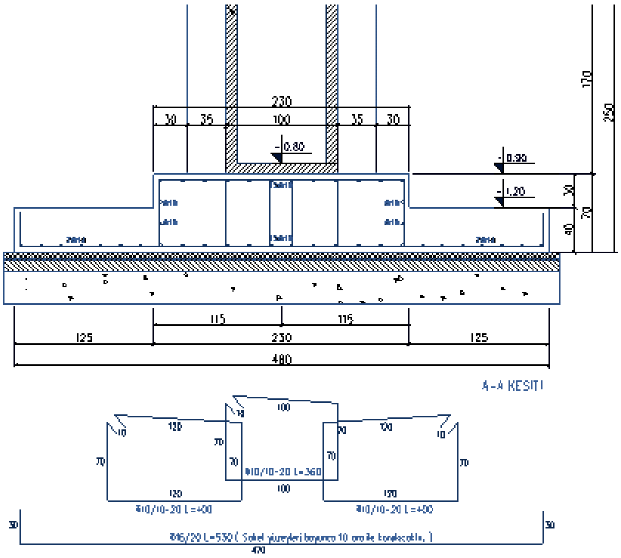

Figure 13. Continuous foundation beam section

7. Conclusions

Precast industrial buildings have become one of the essential structural types that support the continuity of modern industrial production. Their rapid installation, economic advantages, and ability to safely accommodate large spans make them an indispensable component of contemporary industrial facilities. Ensuring uninterrupted operation after an earthquake is crucial for such buildings, which highlights the importance of accurately modeling the seismic behavior of precast systems. In particular, connection regions and the continuity of the load carrying system must be represented with great care, and the design process requires a rigorous engineering approach.

In this study, selecting different values of the structural behavior factor and the overstrength factor for the various levels of the building was considered an important methodological choice. This approach provides a more realistic representation of seismic demand, since the lower portion of the building includes moment resisting frames while the upper portion contains columns modeled with pinned end conditions. Using a single factor for both regions would create an artificial stiffness distribution that does not reflect the actual behavior of the structure and would reduce the accuracy of the analysis. Since the overstrength factor also varies with the structural configuration, this subject has been addressed only in a limited number of studies in the literature. For this reason, the present work offers an original engineering contribution by examining how variations in stiffness between different levels of precast systems influence seismic performance.

The precast reinforced concrete industrial building composed of three halls was analyzed comprehensively in Sap2000 under both static and dynamic effects. The loads included slab, roof, cladding, snow, wind, and seismic actions, and all were defined in accordance with the applicable design standards. Dead loads were introduced in two stages to better represent the construction sequence. Modal analysis results indicate that the natural vibration periods of the structure comply with the limits specified in the code and that the global stiffness of the system remains within the expected range.

Seismic analyses were performed using the modal combination method, and the use of different values of the structural behavior factor and the overstrength factor for different levels of the building allowed a more precise assessment of seismic demands. The results show that the relative story drifts in both the multi-story and the single-story regions remain below the allowable limits. Examination of the internal force distribution, cross sectional capacities of columns and beams, and stress levels in the connection regions further confirms that all members remain on the safe side. The soil structure interaction analyses also show that the allowable soil pressure is not exceeded for either isolated or continuous foundations.

The findings demonstrate that precast reinforced concrete systems are a strong and sustainable solution for industrial buildings in terms of both structural safety and economic feasibility. The study emphasizes that the use of different values for the structural behavior factor and the overstrength factor at different building levels is a critical design parameter for accurately predicting seismic response. By evaluating this approach through a detailed application, the study provides a meaningful contribution to the limited body of literature on this topic.

For future research, nonlinear analyses of precast systems, experimental verification of connection details, and investigation of parameters that influence post-earthquake operational continuity are recommended. In particular, detailed studies on the effects of connection behavior on energy dissipation, ductility, and damage distribution will contribute significantly to the development of safer and more performance-oriented designs for precast industrial buildings.

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Contribution of Researchers

Tezcan Turalı contributed to the literature review, structural analysis, evaluation of structural analysis. R. Tuğrul Erdem contributed to the methodology,

structural analysis, evaluation of structural analysis. Tolga Yılmaz contributed to the conceptualization, evaluation of structural analysis, preparation of graphs, and visualization. H. Selim Şengel contributed to the article writing and editing, translation of the original article text into English.

Conflict of Interest

No conflicts of interest have been declared by the authors.

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