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Contents

Seismic Behavior Analysis of Steel Tower of Self-anchored Suspension Bridge

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Abstract: Self-anchored suspension bridge is composed of tower and its foundation, stiffened beam, main cable, sling, side pier and its foundation, auxiliary pier and its foundation. The performance and importance of the components of the bridge are different. The main tower of self-anchored suspension bridge is a very important component. Once the injury and damage occur under earthquake, it is not only difficult to inspect and repair, let alone replace. This paper calculates the seismic performance of self-anchored suspension bridge steel tower based on the application of Wuhan Gutian Bridge steel tower.

Keywords: Self-anchored suspension bridge; Steel tower; Seismic performance; Analysis

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1. Introduction

The vulnerability of each component of bridge structure under earthquake is different. The main damage of the bridge structure caused by the earthquake are mainly：(1) the damage of the superstructure caused by the failure of the supporting connection; (2) failure of support connections: bridge bearings, expansion joints and shear keys have always been considered to be a relatively weak link in the seismic performance of bridge structure system; (3) tower, abutment, pier failure, serious damage phenomena include collapse of pier abutment, fracture and serious tilt; (4) bridge foundation failure.

Self-anchored suspension bridge is composed of tower and its foundation, stiffened beam, main cable, sling, side pier and its foundation. Under seismic action, the seismic wave is transmitted from foundation to superstructure, and the seismic wave that reaches the upper structure is reflected again and then returns to the foundation of tower pier. The reflection of seismic waves forms the seismic inertia force, and the seismic inertia force of the bridge deck system is fed back to the tower (pier) and its foundation in two directions.

2. Project Overview

The span of Wuhan Gutian Bridge is arranged as (48+57+110+110+110+57+48) m, of which 2 * (48+57+16.5) m is composed of pre-stressed concrete box girder structure, and the rest are composed of steel concrete composite beams in the form of side main girder. As shown in figure 1.[1]

The main tower is a frame structure, which consists of four parts: the lower column, the middle tower column, the upper tower column and the tower top beam. The middle tower column and the tower top cross beam are steel structures, and the rest are concrete structures .The height of the Hanyang side and Hankou side tower bottom (top height of the cap) is 13.50m and 18.50m respectively, and the tower height is 69.624m and 64.624m respectively. The horizontal distance of the tower column bridge is 40m.As shown in figure 2.

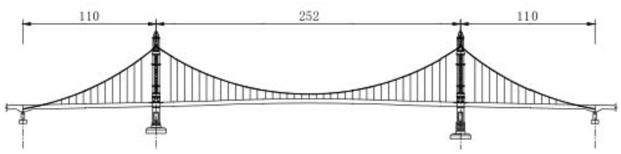

Figure 1. Elevation of Main Bridge (unit: m)

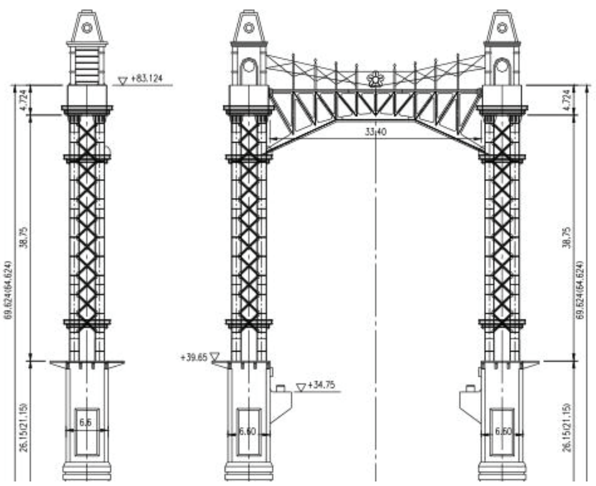

Figure 2. Schematic Diagram of Main Tower Structure (unit: mm)

3. Seismic Performance Targets

The main seismic performance targets of the bridge are summarized as follows:

(1)The main tower, main beam, foundation and other important structural members have no damage under E1 earthquake, and the structure works in the elastic range. Although repairable damage can occur locally under the action of the E2 earthquake, it is required that after the earthquake occurs, the traffic of the vehicle is basically not affected.

(2)Side piers, the components of bridge structure which are easy to repair are not damaged under E1 earthquake, and the structure works in elastic range. Under the action of E2 earthquake, the structure does not collapse and can be repaired after the earthquake, which can be used for emergency rescue vehicles to pass through.

The seismic checking calculation of the main bridge structure according to the aseismic calculation method of Detailed Rules for Seismic Design of Highway Bridges, according to the reinforcement of section, using fiber element, considering the most unfavorable axial force combination under dead load and earthquake action to the main tower and side pier, The control section of the most unfavorable single pile of auxiliary pier and pile group foundation is analyzed by P-M-f analysis, and the bending resistance of each control section is obtained, and the seismic performance is checked and calculated.[3]

4. Seismic Checking Calculation of Steel Tower

The space finite element model is used for the main bridge, the main beam is simulated by the plate beam element, the deck slab is simulated by the plate element, the longitudinal and transverse beam is simulated by the beam element, the cable and suspension are simulated by the cable element, and the sag effect of the cable is modified by Ernst formula. The influence of cable force on the geometric stiffness of the structure is also considered.[4] The towers and piers are simulated by beam element, and the mass is added to the deck of the bridge.[5]

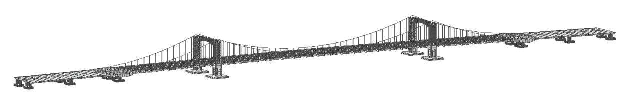

Figure 3. Bridge State Calculation Schema

The strength checking calculation method of steel main tower is allowable stress method.

The main steel tower adopts Q345qD, which conforms to the standard of "Bridge structural Steel" (GBP/T714-2008). The main mechanical properties of the tower can be found in the following steel mechanical property index. [6]

Under the action of E1 earthquake, the increase coefficient of allowable stress value after the combination of seismic load and dead load is considered as 1.5, namely[σ]=1.5*195=292.5Mpa.

Under the action of E2 earthquake, the allowable stress values after the combination of seismic load and dead load adopt yield stress，namely[σs]=315.0Mpa.The results of the physical examination are shown in Table 1:[7]

Table 1. Strength Checking of Main Steel Tower

effect combination	bar	position	The stress (constant load plus or minus longitudinal seismic action) (MPa)	The stress (constant load plus/plus horizontal seismic action) (MPa)	Allowable stress (MPa)	Whether to meet
Constant load plus or minus E1 earthquake action	The towerpos	The bottom of the column	128	150	292.5	satisfaction
Constant load plus or minus E2 earthquake action		The bottom of the column	190	215	315.0	satisfaction

As can be seen from the table, the column of steel tower meets the requirements of seismic design.

5. Conclusion

The spatial dynamic calculation model is established to calculate the dynamic characteristics of the structure based on the example of steel tower of Wuhan Gutian Bridge. The seismic response analysis of the main bridge structure is carried out by using the response spectrum method and nonlinear time-history analysis method. The seismic response of the steel tower of Gutian Bridge under two fortification levels E1 (50 years transcendence probability 10) and E2 (50 years beyond the probability of 2%) has been studied. The checking calculation structure shows that the steel tower of self-anchored suspension bridge meets the seismic performance goal and the safety performance is better.[8]

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Analysis of Common Diseases and Construction Treatment Technologies of Road and Bridge Engineering

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Abstract: In recent years, the rapid growth of the number of private cars has greatly increased the traffic pressure, so the quality of roads and bridges should be further improved. The paper expounds the related matters of road and bridge engineering from three aspects. Firstly, it expounds the construction principles of road and bridge engineering, which are regarded as the theoretical basis of follow-up research. Secondly, it analyzes the common diseases of road and bridge engineering, including bridgehead damage, reinforcement corrosion, and subgrade uneven settlement, etc. Finally, it puts forward the construction treatment technology of road and bridge engineering on the basis of the construction principles and taking the common diseases as reference.

Keywords: Road and bridge engineering; Common diseases; Construction treatment technology

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1. Introduction

As the time goes by, the problems of bridge surface cracks, subgrade settlement, and reinforcement structure corrosion may appear after the road and bridge are put into use, with constant loads from bearing running vehicles. Especially in recent years, due to the increasing number of running vehicles, the possibility of road and bridge disease is further increased. Light road and bridge diseases will affect the appearance of the bridge, while the heavy ones will lead to safety hazards, threatening the safety of pedestrians. In view of this, effective treatment measures must be taken against the possible diseases of the bridge, provided that these diseases are investigated and understood. Strengthening quality optimization in maintenance engineering is one of the effective measures to control the occurrence of road and bridge diseases. Therefore, the designers and constructors of the road and bridge construction unit should continue to conduct in-depth research on the issues related to bridge diseases, and take the research results as the basis to optimize the construction scheme and construction technology to improve the overall quality of road and bridge with respect to the construction process.

2. Analysis of Construction Principles of Road and Bridge Engineering

Given that the road and bridge belong to the main bearing form of road traffic, it is necessary to strengthen the exploration of relevant technologies during its application and development, integrate the application principle and control requirements into engineering design, improve the treatment technology, give full play to the maximum value of the technical mode, and the concrete road and bridge engineering construction principles include the following aspects.

2.1 Maximum Application and Emphasis on Overall Benefits

First, the principle of maximum application needs to be adhered to. In the design of road and bridge engineering, one problem that we must consider is the particularity of bridge structure itself. At the same time, in order to control the structural damage or other diseases at the later stage, it is necessary to use performance analysis and comparative analysis methods to test the bearing capacity of bridge construction and analyze its application reliability for maximizing the original construction.[1] Second, the principle of emphasis on overall benefits needs to be followed. The reinforcement function of road and bridge is more obvious, presenting the reinforcement treatment on weak construction, which can promote the whole system to change in varying degrees; in view of this, before the implementation of reinforcement treatment, a comprehensive assessment of the overall situation of the structure needs to be carried out, to maximize the integrity of the bridge structure.

2.2 Optimizing Design Scheme and Perfecting Construction Preparation

First, the principle of optimizing design scheme needs to be adhered to. When the reinforcement of road and bridge is in the design stage, we need to prepare a variety of optional schemes, taking the existing responsibility system as the basis, considering the overall economic and social benefits of the project, and ultimately define design optimization scheme. The choice of construction scheme and construction technology has a great influence on the quality of bridge construction, and the construction period shall be shortened to meet the construction requirements if permitted. Second, the principle of perfecting construction preparation needs to be followed.[2] Before the construction of road and bridge, the building unit should do a good job in the construction site investigation, which aims to understand the actual construction conditions and incorporate them into the scheme design to ensure the feasibility of the design scheme.

3. Common Diseases of Road and Bridge Engineering

3.1 Expansion Joints

The function of expansion joints is to avoid the structural cracks caused by the change of climate temperature. The expansion joints divide the building above the foundation into two separate parts to ensure that the extension direction of the building can be extended horizontally. Expansion joint devices are mostly located at the end of the bridge, which is more susceptible to the impact of vehicle loads, and is also the most susceptible disease of roads and bridges.[3] Due to the increasing number of running vehicles, the corresponding vehicle load is increasing, which further increases the incidence of expansion joint damage. Once the bridge deck expansion joint damage occurs, it will directly affect the overall adaptability of the bridge, but also may lead to water leakage on the bridge deck, resulting in corrosion of the steel structure.

3.2 Reinforcement Corrosion

Reinforcement is the main building material during the construction of roads and bridges, which needs to be applied in large amount especially in the process of foundation construction. Although the stability of the reinforcement is relatively high, it inevitably will be affected by various natural factors for being used long time, resulting in the rusting of the reinforcement, and even corrosion if not dealt with in time.[4] If the reinforcement of road and bridge is corroded, the oxidation-reduction reaction will occur when it contacts with air. The corresponding oxidation products will increase with the time going by, and then start to expand, resulting in the loosening of the concrete structure around the reinforcement, as well as the appearance of cracks to varying degrees, leading to the reduction of the effective section of the bridge, and its bearing capacity will also be reduced accordingly. In addition, after the corrosion of reinforcement, the area of reinforcement will also be reduced, resulting in the weakening of its own bending capacity and the emergence of these problems will affect the service life of road and bridge.

3.3 Subgrade Settlement

There exists an important link between the foundation of road and bridge and its service life. The uneven settlement of the foundation may cause cracks in the concrete structure of the bridge, thereby reducing the performance of the bridge. The main factors of the uneven settlement of the subgrade include the following aspects: (1) Before the construction of the road and bridge engineering, the personnel involved in the design and construction of the engineering have not made adequate preparations, and failed to make a comprehensive investigation of the construction site, leading to the design of the construction scheme relying solely on the basic information of the project and the relevant standards, which may deviate from the actual construction conditions and result in the lack of rationality in the selection of construction technologies, thus increasing the possibility of subgrade settlement.[5] (2) The constructors, in order to obtain personal benefits, use unqualified building materials, which makes the construction quality not up to the design requirements, giving rise to the irregular settlement of the subgrade. (3) During the construction of the project, the designers and constructors lack understanding of the geological environment around the construction site, plus longer construction period, which will easily lead to the destruction of the underground surface, and the hardness of the soil cannot meet the construction needs causing the uneven stress between the road surface and the bridge deck, thus bringing about the problem of irregular settlement of the subgrade.

3.4 Cracks

The most common problem in the operation of road and bridge is the cracks on the road surface or bridge deck. The reasons for cracks occurred include external environmental factors and construction quality factors. Roads and bridges are continuously exposed to the external environment and are subject to the erosion of wind and rain for a long time. At the same time, they also carry the load of running vehicles. For these reasons, crack problems frequently occur. During the construction of the road and bridge project, semi-rigid structures will be applied to the pavement of road surface or bridge deck. This type of structure will help to intensify the strength and bearing capacity of the pavement. However, such structure is relatively susceptible to temperature changes. The greater the difference in temperature, the likelier it is that there will be cracks on the pavement.[6] For example, during the construction of road and bridge in the northern regions with lower temperature, mostly cracks in pavement of road surface or bridge deck will occur, which is mainly caused by the large temperature difference between days and nights in the northern regions. As a result, the pressure resistance of road surface with semi-rigid structures is reduced, which makes cracks occur more easily after application in the later stage. In addition, in the long-term application process, the incidence of cracks on the roads on which vehicles run is significantly higher than the sidewalks. The reason is that vehicles overload or emergency brake will cause the ground to be squeezed, thus causing road depression.[7]

3.5 Bridgehead Damage

Bridgehead damage is a relatively common problem in road and bridge engineering, which may cause deformation at both ends of the roads and bridges. The appearance of such deformation will further affect the transition of the overall stress structures of the bridges, and the service life and safety of the engineering during operation cannot be completely guaranteed.[8] There is an important link between the occurrence of bridgehead damage and the quality of construction materials. If the building materials used in the construction process fail to meet the design standards, the supporting force of the road and bridge's structural components will be weakened, under pressure caused by running vehicles in long-term application, the bridgehead is subject to local fractures due to the continuous and relatively large loads.

4. Construction Treatment Technology of Road and Bridge Engineering

4.1 Crack Filling Technology

Comparing with repairing technology, crack filling technology performs better in reinforcement effect, and it is more suitable for application in which the crack is relatively wide and the crack problem is extremely serious. The application method of crack filling technology is to dig trenches in the longitudinal depth direction at the location of the road surface cracks, applying cement slurry and epoxy resin glue in the slots to match the specified ratio, and pour the prepared slurry into the road surface cracks.[9] It is worth noting that the performance of epoxy resin glue is relatively stable. After mixing with cement slurry, the destabilization will be further improved, and the road surface cracks can be repaired more effectively. For this reason, mixing with cement slurry should be considered as the main quality control link. In addition, if an appropriate amount of rubber material is added to the matched crack filling material, the cracks can better deal with the impact of a variety of adverse factors, thus achieving the effect of improving the repair quality of cracks.

4.2 Reinforcement Corrosion Treatment Technology

The reinforcement structure belongs to the important bearing structure of road and bridge, which has a great influence on stability and safety of the entire road and bridge. If the reinforcement structure is corroded, it will not be able to continue to be protected by the surrounding concrete. The reinforcement structure losing protection of concrete will increase contact with the outside air, as a result, the corrosion situation is further developed, and the structure toughness will decrease accordingly. In view of this situation, concrete thickness can be increased during construction operations to strengthen the protection for reinforcement structure. At the same time, covering layer and confined layer can also be added to the concrete surface to improve its resistance to external factors. In addition, in the concrete construction process, as the density of the concrete can be increased based on the conversion of ratio of the construction materials, so an appropriate amount of slag and coal ash powder can be continuously added to further enhance the anti-permeability performance of the concrete structure. In addition to the adjustments made in materials and construction methods, it is also necessary to strengthen the management of concrete construction quality and control the occurrence of cracks at the source.[10]

4.3 Subgrade Settlement Treatment Technology

During processing the subgrade, it is necessary to pay attention to the requirements of the bridge reinforcement treatment. For the surface treatment, the cross-sectional area of the bridge needs to be adjusted, which must be carried out through combining the property requirements of structural system. For the requirements of prestress, if the road surface has irregular settlement or settlement in other forms, appropriate treatment methods should be chosen according to the degree of settlement and the form of settlement. The treatment process is as shown in Fig. 1. For the engineering with a relatively small settlement, after understanding the settlement conditions, it is necessary to carry out compaction treatment, and it is possible to select displacement or grouting means to compact the surface based on the action of the road roller. Displacement means to displace soft soil subgrade. In the process of replacement, mortar treatment method can be applied to guarantee adequate structure such as underground soft soil or concrete, and strengthen the bearing capacity and stability of the foundation.

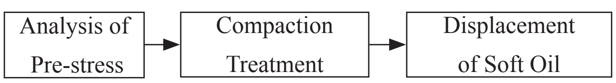

Figure 1. Application Process of Settlement Treatment Technology

4.4 Surface Dressing Technology

Surface dressing technology is ideal in application effect and convenient in operating process, therefore, the cracks existing in the construction process can be effectively treated. Considering the requirements for the bearing capacity of cracks, it is necessary to evaluate the bearing capacity during the treatment and clarify the specific treatment scheme according to the force standard. Surface dressing technology is relatively simple in application process, therefore, constructors can directly find the existing cracks in the surface structure of road and bridge, and achieve crack treatment effects by smearing the cracks. The materials used in the crack treatment include cement slurry and epoxy grout. After the smearing, the surface of the crack needs to be covered with relatively high-quality materials to prevent it from being damaged again after being put into use.

4.5 Bridgehead Damage Treatment Technology

For bridgehead damage, it can be repaired with end damage treatment technology, featured by rapider condensation speed. During the construction period, apply the jetting force of the device to spray the silicone materials to the designated position, and then perform the pouring and tamping operations so that the silicone materials and the bridge can be fully bonded. Silicone materials can meet the requirements of stiffness and flexibility, and the treatment effect obtained after application is more ideal.

4.6 Strengthening Routine Maintenance

During the long-term application of road and bridge, based on the influence of the natural environment and the running vehicles, various diseases will inevitably occur. In response to this, it is necessary to use routine maintenance to control the occurrence and development of various diseases, and to ensure the diseases existing in road and bridge discovered in time and apply reasonable methods to deal with them to avoid causing safety accidents. In the routine maintenance, attention should be paid to the following points: First, after the main construction of road and bridge is completed, it is necessary to cooperate with the traffic department to achieve traffic control to avoid the damage to the roads that are initially condensed by passing vehicles. Second, after the completion of the construction, tests such as earthquake resistance and cracks must be conducted to test the performance of road and bridge. If any index is found not to meet the standard, adjustments must be made until the overall quality of the road and bridge can meet the safety application standards. Third, after the bridges are put into use, it is necessary to regularly inspect and repair the bridges, including whether the surface structures are damaged, whether leakage occurs, whether reinforcements are corroded, and ensure prompt discovery and timely treatment.

5. Conclusion

Light road and bridge diseases will affect the appearance of the bridge, while the heavy ones will lead to safety hazards, thus threatening the safety of pedestrians. In view of this, effective treatment measures must be taken against the possible diseases of the bridge. In the analysis of diseases of road and bridge, it can be understood that cracks, uneven settlement, corrosion of reinforcement, etc. all belong to common diseases of road and bridge. If these conditions cannot be identified as soon as possible, they will be further developed, which will seriously affect the service life of the bridge, and even directly lead to traffic accident. In view of this, improvements need to be made from two levels. First, experience should be summarized in construction to control the factors that may trigger bridge diseases. Second, in the later maintenance, it should discover problems in time and choose the pointed technology for treatment.

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Seismic Response Analysis of Silo-Stock-Foundation Interaction System

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Abstract: To analyze the response law of silo-stock-foundation interaction system under seismic load, a dynamic equation of this interaction system was established. Furthermore, the dynamic characteristics of the silo-stock-foundation interaction system under different storage conditions were studied through numerical analysis. The displacement at the silo top was much greater than that at the silo bottom, while the vibration trend of the upper and lower silos on the same bus bar was similar. The acceleration response, displacement and stress response of the structure increased with the increase of the input seismic wave. Furthermore, the direction time responses of several typical silo parts were consistent. With increase in storage material, the acceleration peak of the silo and bulk material increased and then decreased. This indicates that the relative motion of the storage material and silo had a damping effect on the silo system. The maximum circumferential strain and equivalent stress of silos with different storage capacities were recorded at the variable section of silos (the top of funnel). The effective stress beneath foundations near silos was obviously higher than that far away from silos. These results can provide a reliable theoretical basis and reference values for mitigating silo structural failures under seismic load.

Keywords: silo-stock-foundation system; seismic response; dynamic characteristics; silo-stock-foundation interaction; seismic load; numerical analysis

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1. Introduction

Silo structures are widely used for the storage of various kinds of bulk materials[1-3] (Huachao Ding, 2016; Kunpeng Guo, 2016; Yichen Gao and Guozhi Qiu, 2017). Earthquakes are one of the main causes of silo instability,[4-5] [10-11] (Longfei Yuan et al., 2012; Yang Yu, 2012). Therefore, research on the dynamic characteristics of silos under earthquake excitation is of great practical significance. Domestic and foreign scholars have conducted several theoretical and experimental studies on the dynamic characteristics of silos,[6-8][12] (Chao Ma, 2008; Jinsuo Gao, 2009; Lujian Zhang, 2010; Yingwen Che, 2011; Xianping and Heng, 2011). However, most of these studies did not consider the interaction of silo-storage-foundation system, and focused only on the engineering mechanics characteristics of a single silo[9] (Guansheng Yin, 2002; Jianping Wang and Huang Yi, 2005; Mingping Wang, 2007). Furthermore, studies on the silo-stocking-foundation interaction system are limited and therefore the mechanism of this system is not clear. Since seismic load is one of the primary causes of silo structural instability, studying the dynamic characteristics of the silo-stock-foundation interaction system under seismic load is very important.

Combined with engineering practice, a silo storage foundation system was studied, and a dynamic characteristic model of the silo storage foundation system under different storage conditions was established. Through numerical analysis, the dynamic characteristics of the silo storage foundation system were studied further. The results of this study can provide a theoretical basis and reference values for the seismic design of silo structures that ensures safe operation under special conditions.

2. Basic Equations of Dynamic Model

The silo-storage-foundation interaction system can be regarded as a composite thin-walled cylindrical shell with one end fixed and the other end free. Figure 1 shows the cylindrical shell diagram and its stratification during external periodic load changes. During its movement, the cylindrical shell showed a displacement of each point in the cylindrical coordinate system with u, v, and was the three displacement components, which are simultaneously a function of the spatial coordinates x, θ, r, and time t.

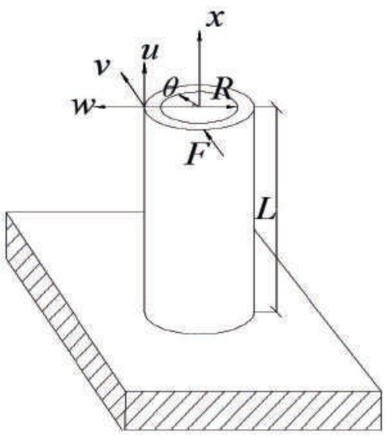


Figure 1. Model of A Circular Cylindrical Shell

2.1 Geometric Equations

The strain component at any point of a thin-walled cylindrical shell has the following relationship with the mid-plane strain, mid-plane bending deflection, and mid-plane distortion, respectively:

$$\varepsilon_x = \varepsilon_x^0 + z\chi_x \tag{1}$$

$$= \quad + \tag{2}$$

$$\varepsilon_{x\theta} = \varepsilon_{x\theta}^0 + z\chi_{x\theta} \tag{3}$$

where ε_x^0, ε_θ^0, and $\varepsilon_{x\theta}^0$ are the film strain components of the middle curve, χx and χθ represent the mid-plane bending deflection, χxθ is the mid-plane twist, and z is the distance from any point on the shell to the middle.

According to the Donnell shell theory, the first-order derivative nonlinearity of the normal deflection is considered in the relationship between the mid-surface strain and displacement.

$$\varepsilon_x^0 = \frac{\partial u}{\partial x} + \underline{\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2} \tag{4}$$

$$\varepsilon_\theta^0 = \frac{1}{R}\left(\frac{\partial v}{\partial \theta} + w\right) + \underline{\frac{1}{2}\left(\frac{\partial w}{R\partial \theta}\right)^2} \tag{5}$$

$$\varepsilon_{x\theta}^0 = \frac{\partial v}{\partial x} + \frac{1}{R}\frac{\partial u}{\partial \theta} + \underline{\frac{\partial w}{\partial x}\frac{1}{R}\frac{\partial w}{\partial \theta}} \tag{6}$$

In Equations 4–6, the underlined items represent nonlinear terms.

In the Donnell nonlinear shell theory, the mid-plane bending strain component remains linear:

$$\chi_x = -\frac{\partial^2 w}{\partial x^2} \tag{7}$$

$$\chi_\theta = -\frac{1}{R^2}\frac{\partial^2 w}{\partial \theta^2} \tag{8}$$

$$\chi_{x\theta} = -\frac{2}{R}\frac{\partial^2 w}{\partial x \partial \theta} \tag{9}$$

2.2 Physic Equations

Considering the elastic modulus of the composite material with vibration frequency changes, it can be obtained:

$$\begin{aligned} &E_1(\omega) = E_2(\omega) = E_3(\omega) = \\ &2.5751\times10^9 + \frac{2\times3.2283\times10^{12}}{\pi}\times\left[\frac{238.62}{4\times(\omega/2\pi - 0.46787)^2 + 238.62^2}\right] \end{aligned} \tag{10}$$

$$E_4(\omega) = 5.04289\times10^8 + 9.2387\times10^9\times e^{-0.0064\omega/2\pi} \tag{11}$$

The physical equation of layer K of the isotropic laminated shell is given as

$$\begin{bmatrix}\sigma_x\\ \sigma_\theta\\ \tau_{x\theta}\end{bmatrix}_k = \begin{bmatrix}Q_{11} & Q_{12} & 0\\ Q_{21} & Q_{22} & 0\\ 0 & 0 & Q_{66}\end{bmatrix}_k \begin{bmatrix}\varepsilon_x\\ \varepsilon_\theta\\ \varepsilon_{x\theta}\end{bmatrix}_k \tag{12}$$

Where Q_i^j is the reduced stiffness matrix, and the element expression is given as

$$(Q_{11})_k = (Q_{22})_k = E_k(\omega)\big/(1-\mu_k^2) \tag{13}$$

$$(Q_{12})_k = (Q_{21})_k = E_k(\omega)\cdot\mu_k\big/(1-\mu_k^2) \tag{14}$$

$$(Q_{66})_k = E_k(\omega)/2(1+\mu_k) \tag{15}$$

Where Ek(ω) is the k-th elastic modulus and μk is the k-th layer of Poisson's ratio.

2.3 Dynamic Balance Equations

According to the principle of D'Alembert, the dynamic equilibrium equation of a laminated composite cylindrical shell can be established as

$$\frac{\partial N_x}{\partial x} + \frac{1}{R}\frac{\partial N_{x\theta}}{\partial \theta} - \sum_{k=1}^{4}\rho_k(z_k - z_{k-1})\frac{\partial^2 u}{\partial t^2} = 0 \tag{16}$$

$$\frac{1}{R}\frac{\partial N_\theta}{\partial \theta} + \frac{\partial N_{x\theta}}{\partial x} + \frac{Q_\theta}{R} - \sum_{k=1}^{4}\rho_k(z_k - z_{k-1})\frac{\partial^2 v}{\partial t^2} = 0 \tag{17}$$

$$\begin{aligned} &\frac{\partial Q_x}{\partial x} + \frac{1}{R}\frac{\partial Q_\theta}{\partial \theta} - \frac{1}{R}N_\theta + N_x\frac{\partial^2 w}{\partial x^2} + \frac{N_\theta}{R^2}\frac{\partial^2 w}{\partial \theta^2} + \frac{2N_{x\theta}}{R}\frac{\partial^2 w}{\partial x \partial \theta} \\ &-\sum_{k=1}^{4}\rho_k(z_k - z_{k-1})\frac{\partial^2 w}{\partial t^2} - c\frac{\partial w}{\partial t} - q_r = 0 \end{aligned} \tag{18}$$

Where can be presented as

$$Q_x = \frac{1}{R}\frac{\partial M_{x\theta}}{\partial \theta} + \frac{\partial M_x}{\partial x} \tag{19}$$

$$Q_\theta = \frac{\partial M_{x\theta}}{\partial x} + \frac{1}{R}\frac{\partial M_\theta}{\partial \theta} \tag{20}$$

3. Numerical Calculation

3.1 Project Overview

The Shenyang Jinshan Thermal Power Heating Project needs setting up of 5 million ton silos with a diameter and height of 22 and 39.730 m, respectively. According to the specification, the silo was identified as a deep warehouse, and lignite coal with a bulk density of 10kN/m3 was used. The seismic fortification intensity was 7 degrees; the basic seismic acceleration was designed as 0.10 g; the seismic structure was fortified at 7°; and the seismic level was 2. The structure received a structural safety rating of 2, fire rating of 2, foundation design grade B, and had a design life of 50 years. Medium-coarse sand was used as the base holding layer is, and the silo warehouse wall was reinforced by pouring concrete. The structure of the cross-section shown is shown in Figure 2.

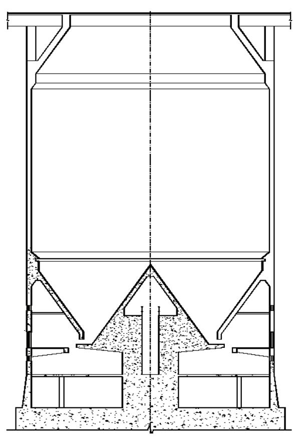


Figure 2. Sketch Map of the Profile of Silo

3.2 Material Parameters

HRB335 steel is selected for the silo steel, and the strength of concrete is C40. The silos were filled from the top to bottom of the foundation with soil (1 m), silty clay (5 m), coarse sand (2 m), and gravel sand. The base holding layer was medium-coarse sand, and the surface fill layer was very thin. For simplified calculation, the mechanical parameters of the material are equivalent to silty clay. The lignite was stored in the silos.

3.3 Contact and Boundary Conditions

The model uses smoothed particle hydrodynamics particles as nodes, which are in point-to-surface contact with the silo wall. The dynamic friction coefficient between storage material and silo wall is 0.5, and the static friction coefficient is 0.9.

The upper surface of the foundation soil is a free boundary condition. The surrounding of the foundation soil is set as the nonreflecting boundary condition to avoid the influence of the reflected tensile wave on the calculation results and to restrain the normal displacement of the boundary surface. The normal displacement and rotational freedom of the ground surface node restraint release two horizontal displacement components.

3.4 Finite Element Model

In this study, the finite element software ANSYS/LS-DYNA3D was used to build the silo-foundation model according to the actual project size of 1:1. As shown in Figure 3, the bonding between the silo and foundation is used to ensure the continuity of the displacement. The total is divided into 32,640 units and 36,656 nodes. The Lanzhou wave was selected as the input seismic wave in the numerical simulation, the time history curve and spectrum curve of the Lanzhou wave are shown in Figure 4.

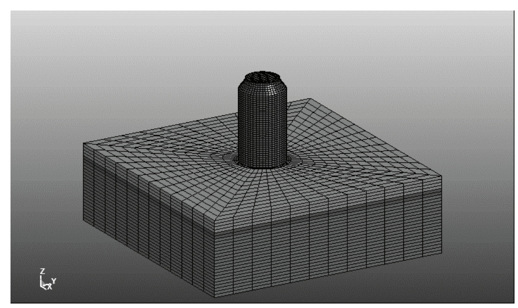


Figure 3. Schematic Diagram of the Model

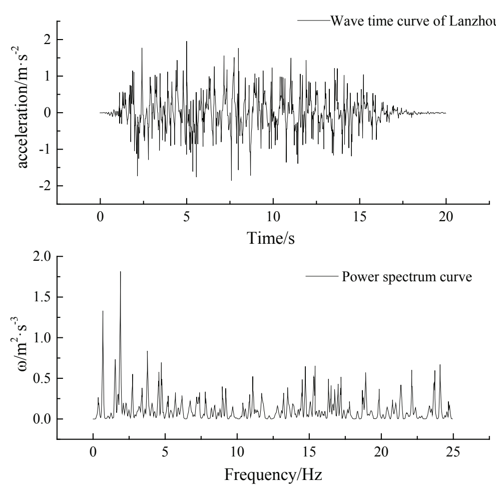


Figure 4. The Time History Curve and Spectrum Curve of Lanzhou wave

3.5 Seismic Response Analysis

3.5.1 Time History Analysis of Displacement and Acceleration

Under the action of seismic waves, the displacement and acceleration peak curves of the nodes at the top of the silo, the junction of the silo, and the ground and top of the storage material, are shown in Figure 5.

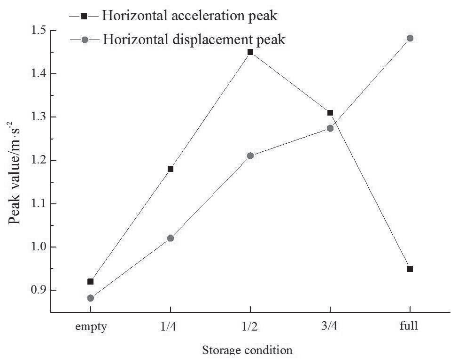


Figure 5 (a). Time Curves of Displacement and Acceleration at the Model's Monitoring Points

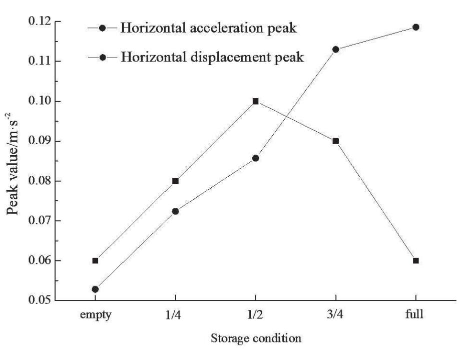


Figure 5 (b). Time Curves of Displacement and Acceleration at the Model's Monitoring Points of Silo-to-Ground Interface

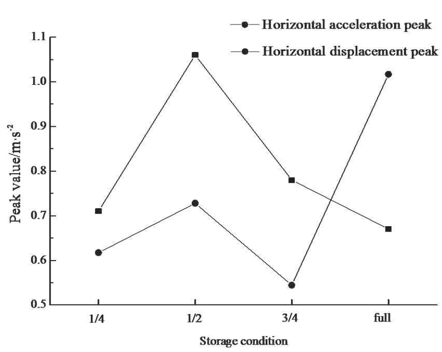


Figure 5 (c). Time History Curves of Nodal Displacements and Acceleration at the Top of the Storage Material

The analysis shows that the displacement at the top of the silo is far greater than that at the bottom, and the trend of the upper and lower silos in the same bus bar is similar. The larger the input seismic wave, the greater are the structural acceleration response, displacement deformation, and stress response. From the point of view of the whole structure, the movement directions of the time histories of several typical silos are consistent, indicating that the entire body of the warehouse is swinging.

With the increase in storage, the peak acceleration of silos and bulk materials first increases, and then decreases, indicating that the relative movement of the storage and silos has a damping effect on the silo system.

3.5.2 Silo and Storage Material Effective Stress Analysis

Figure 6 shows the effective stress maps of silos and silos under different storage conditions when the displacement of silo nodes and storage nodes reaches their peak.

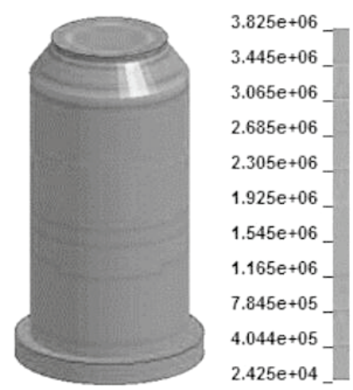
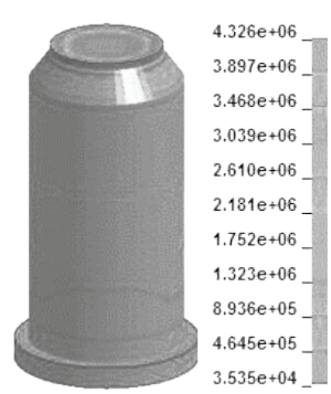


Figure 6 (a). Silo Effective Stress Cloud Chart under the Condition of Short Position

Figure 6 (b). Effective Stress Cloud Chart of Foundation under Empty Condition



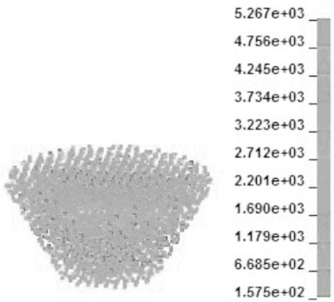


Figure 6 (c). Effective Stress Cloud Chart of Silo and Storage under 1/4 Storage

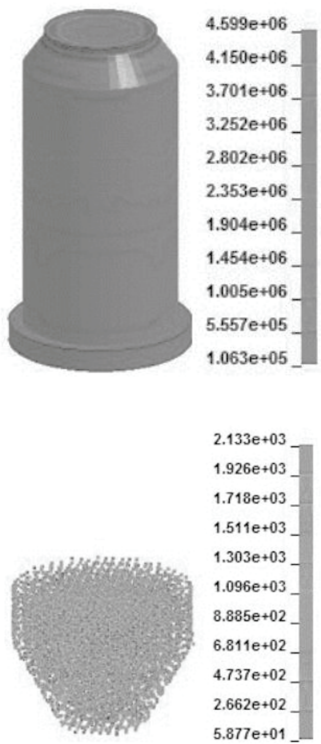
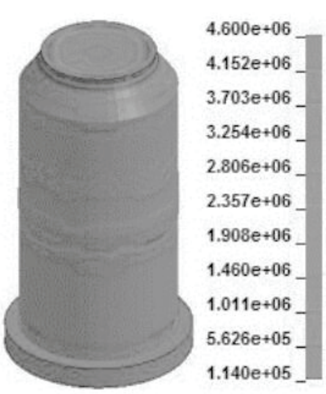


Figure 6 (d). Effective Stress Cloud Chart of Silo and Storage under 1/2 Storage



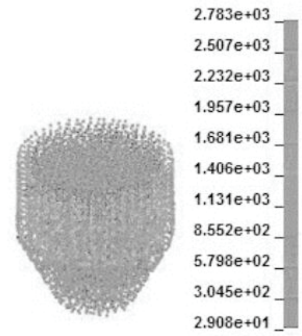


Figure 6 (e). Effective Stress Cloud Chart of Silo and Storage under 3/4 Storage

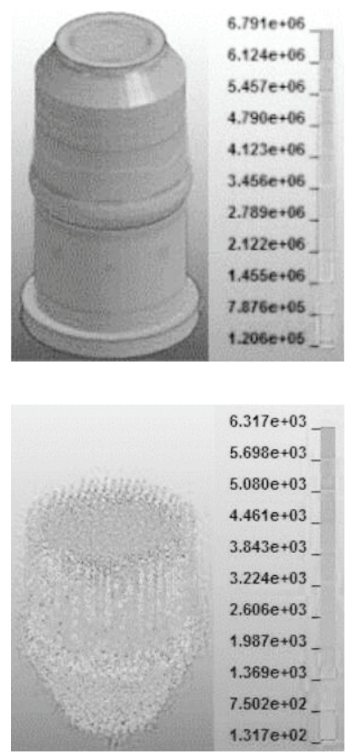


Figure 6 (f). Effective Stress Cloud Chart of Silo and Storage under Full Storage

Figure 6. Effective Stress Cloud Chart for Silos and Storage Material under Different Storage Conditions

As can be seen from Figure 6, the maximum circumferential strain and the maximum equivalent stress of silos with different storage capacity all appear at the variable section of silos, namely the top of funnels, and should be strengthened in the design of silos. The effective stress in the subgrade of the silo foundation is obviously higher than that in the far zone, and the foundation of the base area should be strengthened to avoid the instability of the foundation.

4. Engineering Examples of Optimal Design

4.1 Silo Structure Optimization Background

The test methods mostly calculated the moment of the basement by measuring the hoop strain and the vertical strain at the bottom of the silo test model, combined with the elastic modulus and Poisson's ratio from the model. In the numerical model, a node along the Z-axis of the force component was multiplied by the node at the base of the silos, formed by the central X-axis component, and then all the results of the node were used to obtain the value of the base moment. "Code for Design of Reinforced Concrete Silos" GB 50077-2003 states that the moment of the base can be calculated as follows:

$$M_{Ek}=\alpha_1 (G_{sk}h_s+G_{mk}h_m) \quad (21)$$

where, α_1 is the horizontal seismic influence coefficient of the basic natural vibration period of the structure, G_{sk} is the representative value of the silo weight gravity load, G_{mk} is the representative value of the total weight of the gravity load, M_{Ek} is the standard value of the moment at the bottom of the silo, h_s is the height of the center of gravity of the silo, and h_m is the total weight at the center of gravity height.

A comparison of the model test, numerical simulation, and standard calculations of the bending moment of the silo base under different loads is listed in Table 1.

Table 1. Comparison Results of Base Bending Moment Values of Silos

Base moment ($N•m$)	Short positions	1/4 positions	1/2 positions	3/4 positions	Full positions
Test results	950	1223	1587	1963	2274
Simulation results	1981	2341	2872	3256	3899
Specification calculation	1633	2018	2295	2684	3026

As can be seen from Table 1, the formula given by the specification is too conservative and will result in greater material waste. The original design can therefore be optimized using our method.

4.2 Silo Structure Optimization

4.2.1 Basic Optimization

The silo is a tube-supported reinforced concrete silo, the original design of the base plate is square, the base plate thickness is 2.5 m, and the base depth is -5.77 m. After optimization, the base plate was changed to a circular shape. The thickness of the base plate was optimized to 2.3 m by reducing the thickness by 200 mm. The base depth was increased to -5.77 m and the depth of the base was reduced by 200 mm.

4.2.2 Roof Thickness Optimization

The thick structure of the top of the silo not only causes material wastage, but also the excessive weight of the top of the silo will increase the center of mass of the silo structure, increase the rigidity of the silo, and thus increasing the natural frequency of the silo and intensifying the displacement of the top of the silo under the influence of a horizontal earthquake, compromising structural safety. To this end, the thickness of the roof structure after optimization was reduced from 2.0 m to 0.8 m. The top of the silo warehouse is designed as inverted conical shell structure. The silo roof reinforcement was calculated by SILO alone to reduce the height of the silo wall and reduce the amount of reinforcement and the amount of concrete in the silo wall.

4.2.3 Silo Reinforcement Optimization

The PKPM silo module was used to optimize the model. The calculations showed that the spacing between the annular steel bars in the cylinder wall could be optimized from 125 mm to 135 mm, which greatly reduces the amount of steel used. Figure 7 and Figure 8, respectively show the optimal design of the silo structure reinforcement and the resulting crack model.

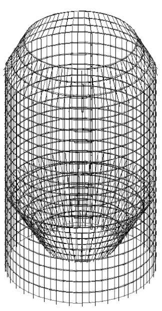


Figure 7. Structure Reinforcement Diagram

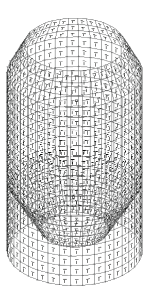


Figure 8. Crack Map

4.2.4 Other Construction Measures to Optimize

Considering to the change of temperature difference in winter in Shenyang and the mechanical properties of concrete under this temperature, the thermal insulation of the outer wall of the silo was removed.

4.3 Silo Optimization Results Analysis

4.3.1 Comparison of Engineering Quantity before and after Optimization

The results of the comparison of silos before and after the optimization are shown in Table 2. As can be seen from table 2, the original design of a single silo cost about 50 million yuan, and the cost of a single silo was reduced by 10 million yuan by optimizing the design. The total cost of the whole project would therefore be reduced by nearly 50 million yuan, conserving the quality of the project and achieving favorable economic benefits.

Table 2. Comparison of Engineering Quantity before and after Optimization of Silo

Optimization indicators	Unit	Before optimization	After optimization	Change due to optimization
Amount of steel used	T	2372	1935	-437
Amount of concrete used	m^3	17367	14332	-3035
Tube wall outside the insulation (MU7.5 porous sintered brick)	m^3	2875	0	-2875

4.3.2 Analysis of Silo Settlement after Optimization

The 5-tonne silo of the Shenyang Jinshan Thermal Power Plant 2×200 MW "Large Generation" Heating Project coal handling system has been operating safely for nearly 10 years since it was first put into production. No cracks have occurred in the silo wall, and the supporting structure has not affected normal production. The foundation settlement stabilized 12 months after it was put into operation, with no uneven settlement. The settlement value peaked at 33 mm, meeting the requirements of relevant specifications. The settlement volume two years after commissioning is shown in Figure 9. This proves the conservativeness of internal force calculation and the rationality of silo optimization under the action of horizontal earthquakes. The optimal design methods presented here should therefore be popularized and widely applied.

5. Conclusion

The silo displacement of the silo top is far greater than that of the bottom, and the trend of the upper and lower silos in the same bus bar is similar. The structure acceleration response, displacement deformation and stress response increase with the increase of input seismic amplitude.

From the whole structure, several typical parts of silos of the time-course response to the movement of the same direction, indicating that the overall swinging warehouse body. With the increase of storage, the peak acceleration of silos and bulk materials first increases and then decreases, indicating that the relative movement of storage silos and silos has a damping effect on the silo system.

The maximum hoop strain and the maximum equivalent stress of silos with different storage capacities appeared at the top of the funnel at the variable cross section of the silo, and the effective stress in the silo near the foundation was significantly higher than that in the far zone.

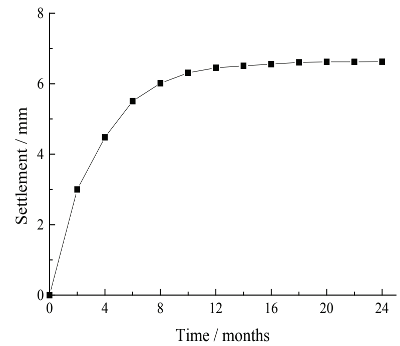


Figure 9. Settlement Curve of Silo

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Research on the Integral Practical and Aesthetic Design Teaching of Architecture and Site Environment

—Taking Kindergarten Architecture and Site Logic Model Teaching Approach as an Example

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Abstract: The integral practical and aesthetic design teaching of architecture and site environment is expected to deal with the junior-grade design teaching in architecture major with a current situation that the insufficient consideration of the site environment and the chaotic city image, which caused by long-term emphasis on single function and personality performance of architecture. The key to the integral practicability and aesthetics is the emphasis on the integrality of spatial logical order of those two factors, which contains the integral harmony of function attributes, scale, logics, and modal relationships and so on. Combine with the teaching of kindergarten architecture design, using architecture and site logic model teaching methodology, through the extraction cognitive teaching approach of the site environment order logics, the cognitive teaching approach of kindergarten architecture spatial logics, the strategic teaching approach of the congruent design of the integral order of architecture and site environment logics, module and model congruent counterpoint design teaching approach of architecture and large site environment order logics, organization and construction integrated design teaching approach of architecture and small site environment spatial logics, and result design teaching approach of architectures integrated into the landscape of large site environment and their surrounding small site environment and other teaching procedures to complete the teaching tasks of the integral practical and aesthetic design of kindergarten architecture and site environment.

Keywords: Site environment; Teaching approach of architecture design; Architectural design logics; Architecture model; Teaching approach of architecture logics.

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1. Introduction

"Site" in architecture discipline is referred to "a site or place designated or recommended for building architectures, implementation schemes or parts of them; the specific locations of buildings and building groups".[1] Different from the emphasis of "place" on historical sense, "site" emphasizes the logics of the current situation in its surrounding environment.[2]

The integral practical and aesthetic design teaching of architecture and site environment is expected to deal with the junior-grade design teaching in architecture major with a current situation that the insufficient consideration of the site environment and the chaotic city image, which caused by long-term emphasis on single function and personality performance of architecture; meantime, it also conforms to the development trend of urban design which is a product to deal with the senior-grade urban design teaching.in architecture design major. The site environment mentioned in this article includes two levels: first, Large site environment refers to the large site environment that contains a correlation of building site and range site. For example, the community should include the main entrance and exit, the public space of the community, and the buildings surrounding the site. The small site environment around the building mainly refers to the site environment within the construction site area and surrounding the design building.

2. The Current Situation of Insufficient Attention to the Architecture Design Teaching Site Environment by Domestic Architecture Education

For a long time, the domestic construction education has paid more attention to the practical and single appearance of the architectural space function, and the relevant venue teaching has mainly concentrated on the technical issues such as the site vertical treatment. The feedback from the architectural design course on the site environment focuses on meeting the requirements for planning exit line and entrance/exit location. For the logical scale relationship and modality relationship between the building space and the site environment, the site environment and the construction environment are less practical and practical. This has caused students to pay more attention to the aesthetic appearance of building blocks, the design of building space and the offline environment.

3. Advocate the Development Trend of the Integral Practical and Aesthetic Design Teaching of Architecture and Site Environment under the Background of Urban Design Development

The integral design of the site environment is the subject of many researches in the interior and exterior architectural circles under the background of urban design development. It promotes the spatial design of the building and its external space environment in a rational way, combining the environmental and external environment, and enters the site environment. And becoming an important shaper of the site environment has gradually become the consensus of the design community. With respect to the urban design of the new large-scale urban districts (especially the design of the new urban central district), the constraints and problems of the architectural and environmental design in the specific site environment are more direct to the teaching of architectural design in middle and early grades. The basic design concepts and the basic stages of the basic design for solving the problem are important. Therefore, in this stage, the overall design concept of the building and site environment of the students' site environment and architectural space is established from the source of architecture education, and a corresponding set of design is taught. The strategy approach is very necessary.[3]

4. Discussion on the Integral Practical and Aesthetic Design Teaching of Architecture and Site Environment (Taking Kindergarten Architecture Design Teaching as an Example)

The key to the integral practicability and aesthetics is the emphasis on the integrality of spatial logical order of those two factors, which specifically contains the integral harmony of function attributes, scale, logics, and modal relationships and so on. The kindergarten architecture design teaching course is in the transitional stage of design teaching from the lower grade (second grade) to the middle grade (third grade). It is the first public architecture with comprehensive functions that the students have come into contact with. The site of the architecture is generally located in the community. The relationship between its architectures and the surrounding site environment is very close. In the specific teaching, Combined with the teaching of kindergarten courses, We have had a preliminary discussion on architecture and site logic model teaching methodology, through the extraction cognitive teaching approach of the site environment order logics, the cognitive teaching approach of kindergarten architecture spatial logics, the strategic teaching approach of the congruent design of the integral order of architecture and site environment logics, module and model congruent counterpoint design teaching approach of architecture and large site environment order logics, organization and construction integrated design teaching approach of architecture and small site environment spatial logics, and result design teaching approach of architectures integrated into the landscape of large site environment and their surrounding small site environment and other teaching procedures.[4]

Due to the influence of contemporary management and teaching approaches, the domestic kindergartens have a typical unit model for class placement, which makes it possible to modularize their building space. In combination with our school's kindergarten architecture design teaching, we have proposed an approach of using architecture and site logic model teaching approach to discuss t the integral practicability and aesthetics of kindergarten architecture and site environment.

4.1 Relevant Teaching Approaches

For this teaching process, combined with the kindergarten architecture design course, we gradually established specific teaching methods such as the architectural and venue logic model teaching approach, in order to promote the students' grasp of the site environmental issues. The teaching method teaches through a design model that reflects the spatial logic of the site environment and architecture, emphasizing the logical relevance of the design teaching process.

The major scope of the course preparation stage is mainly to set up four stages of the model (including the main entrance or center of the community, etc.), a large proportion (generally 1:200), and an overall site environment model that can reflect the logic of site order; The architectural model of the overall model of the implanted site that explores the logic of the site environment and landscape order; the third, the overall structure of the architectural and environmental spatial logic that matches the site environment (combined with the reasonable unit combination of the site environment) Construct a design model of the external environment of the building (integration of the architecture space); Fourth, the model of the environmental outcomes of the building integrated into the large-area environment and the design of the surrounding small-site environmental results.

4.2 Teaching Procedures and Content Arrangement

4.2.1 The Extraction Cognitive Teaching Approach of the Site Environment Order Logics

Teaching content: Through the topic site visits and the large-scale environment model (if the community can best reflect the community entrance and the central square green space, etc., a 1:200 ratio can be used to implant the same proportion of the building results model), Intuitively guide the students of lower grades to learn the spatial sequence of cognitive venues, including spatial sequence, primary and secondary levels of open space and other relevant content. For the junior grades, the focus of teaching should be on the main entrance and exit location of the community or urban local environment, the direction of the flow of people, the open space of the community or the big environment of the city, and whether there is any connection with the design of the small space and so on.[5]

4.2.2 The Cognitive and Applied Teaching Approach of Kindergarten Architecture Spatial Logics

Through the analysis of similar cases, textbooks and other means, we can understand the spatial function types, spatial scales, and the basic constitutional logic of kindergarten architectures. The logic of its composition can be summarized from two aspects of natural order and social order by using inductive deduction, and it can put forward its own spatial organization logic in combination with the conditions of the project site. The illustration shows the spatial unit weaving method and its spatial organization discussed by student Xiao Hu.

4.2.3 The Strategic Teaching Approach of the Congruent Design of the Integral Order of Architecture and Site Environment Logics

The integration of the architecture and site environment logical order means that the architectural space order should be harmoniously integrated into the site environmental order, and form an overall site environment space with other building or site environment components. Its design strategy should include the strategic logic attribute of the architectural space and site environment, the alignment design, the scale logic matching design, and the modal logic matching design.

The logical design of the architecture space and site environment function refers to the design that the space function attributes such as dynamics, privacy, and public of the building space should be matched with the functional attributes of the large site environment. The construction and the surrounding small site environment must be practical. At the same time achieve maximum space benefits.

The logic matching design of architecture space and site environment scale means that the scale of the architecture space should match the scale sense of the surrounding architectures and the environment, neither abruptly nor oppressively, nor is it due to smallness and deficiencies.

The logical matching design between architecture space and site environment ambiguity refers to the echo and match relationship between the architecture space form and the site environment and the existing forms of the architecture through the design.[6]

In teaching process, the above strategies and design approaches should be used in conjunction with the characteristics of the junior grade students to carry out relevant teaching approaches. For example, students are required to master the matching of functional attributes through teaching, to understand the spatial scale matching design, and to understand the possible approaches and means of modality matching design.

4.2.4 Module and Model Congruent Counterpoint Design Teaching Approach of Kindergarten Architecture and Large Site Environment Order Logics

Kindergarten architecture logic should be consistent with site logic from functional attributes, scale relations, and modal relationships. The main function unit of the kindergarten is made into a flower mud or foam module model (the dark green part is the module of the kindergarten's functional units), and the layout and alignment design are performed on the site environment model so that the functional attributes of the two are aligned. Scales and relationships are consistent, modal relationships echo each other, and students intuitively understand the integral design process of spatial logics.

4.2.5 Organization and Construction Integrated Design of Kindergarten Architecture and Site Environment Spatial Logics

Kindergarten architecture space (inside) and site environment (external) space organization and interior and exterior integration of space construction are designed, and the two complement each other and integrate into each other. Space-based integration design mainly refers to the intrinsic link between the spatial organization logic of the architecture and the surrounding site environment and the overall design. It also includes ethical order, functional logic, scale logic, and modality relationships, and at the same time, the surrounding of the architecture. The site environment should form a buffer and transition between the site environment and the architecture space.[7] The spatial constitutional design means that the constituent elements and constitutional forms of the space and space in the environment surrounding the architecture and its surrounding areas should have intrinsic connections and be integrated in the design.[8] Through that process, students are fully aware of the internal and external correlations between architecture space and site environment space and the relevance of design techniques.

4.2.6 Result Design Teaching Approach of Kindergarten Architectures Integrated into the Landscape of Large Site Environment and Their Surrounding Small Site Environment

Through the integration of a large site environment and a result model that includes the design of a small site environment (which can be performed in conjunction with computer-based solid modeling), students can further understand the relationships between the site environment and the architecture space and recognize the significance of the integral design.

5. Conclusion

The Conclusion contains summary and improvements of teaching characteristics.

5.1 Summary of Teaching Characteristics

(1) Emphasize on method teaching.

(2) Emphasize the controllability and intuition of the design process.

(3) Emphasize the authenticity of the course site environment and the sense of presence of the design.

(4) The logical relevance and procedure gradualness of the course link settings.

Each design process of model control has a strong pertinence, and there is a strong logical relationship between the teaching links, meantime with the front and back courses related to each other; teaching procedures are arranged at every level, whose links can give students a step that can be achieved through hard work, and thus students can gradually grasp the related approaches to combining the site environment to start designing.

5.2 Improvements of Teaching Characteristics

Architecture and site logic model teaching approach effectively helps students to recognize and deal with the logical relationships of the site environment, but at the same time, the design based on the existing spatial model also constrains the exploration of the essential needs of the kindergarten, which requires the reinforcement of the kindergarten unit space and its organizational design in teaching to encourage students' creative aspirations.

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University Campus Gates as a Tool of Identity Representation

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Abstract: With information age, it has become one of the primary aims of universities to contribute to transforming knowledge into social power. The university institution has to establish a domain of influence spreading out from the micro-scale without isolating itself, because the knowledge produced must respond in social life and enter public circulation. This micro scale should be the urban environment in which the university is physically located. Therefore, today's universities should first strengthen their relationship with their immediate surroundings, starting from the nearest. Within the plurality, fluidity and complexity of social life, the process of building identities for individuals is an obligation. Similarly, public institutions also have to separate themselves from the context they are part of and establish their own identities. While doing so, university institutions put their special qualities in the foreground and design the representation of their institutional structures for the outside world. In this sense campus gates have great importance as the interface between city and university. These architectural constructions, which are designed as introductory buildings to represent the university, are the places where physical interaction between city and university first takes place. The aim of this study is to discuss the architectural qualities of campus gates of universities in Turkey and try to decipher the forms in which identity formation takes place through given examples. In order to create a general panorama the examples were chosen without any distinctions such as private/state University, urban/ non-urban University, old/new university, etc.

Keywords: Architectural design; Identity; Campus gates; City; locality

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1. Introduction

The information age we are going through necessitates the production and control of information for societies that have to sustain their existence and their integration in the globalizing world. Universities are the institutions influenced by the transformation at the most, and they have to adapt the developments in the world of information in order to exist. This is because universities are the very places where the production and consumption of information are centered around, and the means of information vary most.[1] Universities are the latest and widest circle in the education and schooling sequence of societies,[2] and their duty is to transform the regular individuals into qualified ones through education. The main aims and responsibilities of the universities are to produce and spread knowledge and ideas.[3] The information age holds universities responsible for considering information as a social concern and for direct contribution to its development as a social strength.[4]

The information produced should correspond to the realities of social realm, and get into public circulation; universities have to create a sphere of influence to contribute such circulation starting from their micro scale, which is first and foremost the urban space the universities physically exist. Therefore, the modern universities have to enhance their relationships with their close environments, and to transform the potentials they produce into surplus value.

In Turkey, 92 new universities have been established in the last ten years, and the number of universities reached to a total of 196. The recent government policies include the motivation to provide at least one university in each and every city, and the universities established have to position themselves in such competitive environment with their autonomous structure.

The plurality, liquidity and complexity of social life, institutions, similar to individuals, have to construct their identity to differentiate from others, and to become special in the sphere they belong to. Universities design the representations of their institutional structures and emphasize their special characteristics while constructing their identities. Campus gates are of utmost importance since they are the spaces where the relationships between the cities and the universities begin. These architectural structures do not only function as the entrance to universities, but also work as interfaces between them and the cities, and as tools of their identity representation. This paper aims at deciphering the identity construction processes in a number of cases by analyzing the architectural characteristics of campus gates. In order to reach to a general panorama, the samples have been chosen by a criterion of architectural quality, regardless of whether the universities are state or foundation universities, whether they are inside or outside of the cities, and whether they are new or old.

2. "Identity" as a Concept

The word "identity" is defined by the Turkish Language Association as follows: "1.The entirety of all the distinguishing attributes, features and characteristics of an individual as a social being, which make him/her who s/he is. 2.Document or ID card that has someone's name and other information about him/her. 3.The entirety of all the characteristics to distinguish an object."[5] This definition limitedly attributes "identity" to individuals and objects; however, today each and every "thing" needs an identity ontologically. This identity might voluntarily be determined, or it can be a process the context of which would be constructed in time. Identity, thus, cannot be limited to a concept which defines human beings only.

City, in its narrowest sense, is defined as "a settlement, the population of which mostly deal with trade, industry or administration; where agricultural activities do not take place".[5] Non-agricultural production is dominant in the city where the means of production and population centres around. The city is consisted of high levels of integrity, while uniformity cannot be observed.[6]

Universities are institutions directly related to urban formations, thus, the concept "urban identity" is also crucial for our topic. Cities are in a continuous process of improving the qualities of the services they provide, and of keeping up with the times in an ever-transforming global world order; so they complete their structural development and review their administrative mechanisms. This structural and administrative evolution is determined by globalization. Globalization shrinks the world, and at the same time emphasizes fragmenting differences paradoxically. The variety of local cultures emerged in such a way that competition among the localities and cities is stimulated. Intense improvements in international communication have made the interaction between the local and the global much more intense, and have resulted in the emergence of new fragmentations and "localities".

Lynch defines "identity" as the originality and difference of an object from all others, and claims that identity is not identical to anything else; it is unique.[7] Prohansky, Fabian and Kaminoff define the identity of a city, which it has as a place, as a base of individual identity. It is a compilation of memories, ideas, interpretations, opinions and emotions on specialized physical settings. The identity of a place is a sense of belonging to that place stemming from the identity of it.[8]

According to Bott, Cantrill and Myers, place is an outcome of the merging physical and cultural characteristics together with individual interactions and needs.[9] Bott, Cantrill and Myers' approach to identity also includes the formation of identity of place by specialized and distinct symbols as a product of various emotions. These symbols emerge as the first impressions and experiences of the place in the first encounter. Ardoin emphasizes the spirit of the place too, and defines four dimensions of it as follows:

(1) Bio-physical or physical formations that influences the buildings and the natural environment;

(2) Individual psychology determined by the physical context of the place;

(3) Socio-cultural elements related to social communities and cultural concepts;

(4) Political and economic elements as the reflections of local procedures.

Departing from these definitions of place and its identity, it can be claimed that global world imposes the possession of a well-defined identity, which contains the physical and social characteristics of urban spaces, and becomes crystallized as the set of constrained features of the city. Thus, all the elements that exist in the city are to contribute the formation of its identity. At the end, the values which belong to the city determine the definition of it. Therefore, each city has a distinct image, and this image is the identity of that city.[10]

The discussion on the identity of cities has a direct impact on universities. As will be seen in the further chapters of the present study, universities mostly stick to the identities of the cities they are built in while constructing their identities. Institutional identity is determined by the institutional dynamics; however, contextual dynamics also get involved. Corporate identity, similar to individual and urban identities, is the way of representation of that institution. However, unlike them, the basic characteristics of an institution are produced from the scratch, and thus the corporate identity can be designed from scratch.

As claimed above, institutions also have their own distinct identities, characters, virtues and traits that make them different from the others. Identity is not for human beings only; all the organizations, institutions and establishments, which have various roles in the social realm, have their own identities.[11] The identity of an institution is the entirety of the forms the institution represents itself; and identity is defined as follows: "The entirety of activities which direct the perception of the institution's representation." Initial visible aspects of the corporate identity are logos, business cards, headed letter papers and so on. However, a corporate identity necessitates institutionalization first.[12]

Highhouse et.al., in their survey in the corporations such as American Express, Dow, Exxon, and General Electric, showed that companies which actively carried out their corporate identity operations attracted employees more than others.[13] Van Den Bosch conducted a survey across 20 big companies in Netherlands, and came to the conclusion that evaluations on visual identity increased the awareness about the elements of visual identity, and emphasized the importance of visual elements in the formation of identity.[13] Luthesser claims that, corporate identity starts with the establishment of the corporate mission which transmits the philosophy of the institution to the participants, and emphasizes the importance of institutional mission in the formation of corporate identity.

These all about corporate identity are valid for the university as an institution. Each university constructs a corporate identity to represent its characteristics, starting from its immediate surroundings. Various means are employed in various mediums throughout this process, and what is expected is a consistent whole. While constructing its identity, a university has to be selective about many aspects, such as the position of its campus in the city, the architectural language it employs in the design of the campus, its logo, and the academic fields in its structure.

This research explores how universities construct their identities with the campus gates they employ as a surface to interact with the cities they are located in, and how the formal languages of these gates integrate the present identities and dynamics of those cities. Formal, symbolic and spatial proofs will be presented in this paper.

3. The Relationship between the University and the City, and the Gate as an Architectural Interface

"University" is defined as "an educational institution which has scientific autonomy and public entity, consisting of faculties, institutes and colleges, which practice scientific research and publishing, and which are governed by the same directorate". The word "university" in western languages originates from a word of the late Latin language, "Universitas", which means "whole, unity, community". Its recent common usage implies its character to be open to all the society, and defined as "the place / institution where all sorts of knowledge is produced and taught".[14] Wissema explains the development of university in time throughout generations, and categorizes universities in three historical phases: Universities of Middle Ages (the first generation), Humboldt Universities (the second generation), and the third generation universities.[15] The institution has had its recent form in the post-industrial period, and starting from its former phases, it has developed its efforts to make the knowledge public, getting involved in increasingly complex relations with social and political contexts. Modern universities, in addition to their traditional functions such as education and research, have further national and international financial missions such as research collaborations with the private sector and licensed inventions; and these missions also have influence on their close environments.[16] Universities now have to strengthen their relationships with the cities they locate in. In Turkey, the relationships of the universities with the cities they locate in have not been so close, since the knowledge-production function of the universities is considered to be universal and international, and the local relationships of the universities have remained in the background.[17] Until 1950s, the universities in Turkey were built inside the cities, and many of these campuses still remain. Faculty and college buildings of many universities have been developing in urban areas, old buildings are renovated, and new buildings are erected whenever ground plots are available.[18] The universities located in the cities become parts of the cities in city blocks accessible for urban usage. They make use of urban services; however they are always subject to reconstruction and rezoning threats.[19] University-city relationship in its idealized form, however, cannot be observed in the universities in cities in Turkey. Most of the time, the campuses are isolated from the city with great walls which do not allow a permeability between the urban population and that of the university. One or a few gates of the campuses cannot satisfactorily integrate the university and the city, since access control points for security purposes make it worse.

The cities located out of the cities have self-sufficient campuses which include not only educational, research and operational buildings, but also buildings for all the necessary functions such as dwelling, entertainment, shopping, sports, health and recreation.[18] Such campuses are not involved in the urban life and traffic outside campus. They are closer to nature. They generate their interior commune, and the social ideas are reflected in the physical planning of their microcosmic cities, i.e. their campuses. The idea of campus, applied in USA first, stems from the "castrum" of the middle ages, and it is defined as "repeating units in a unified order, and formation of the whole consistent with the basic idea, with the development of such units".[20] The most appropriate location for a university campus is the immediate outskirts of the urban areas.

University, in his opinion, should integrate with its environment in such a way that open spaces of the campuses must be accessible by the public, and the dormitories should be in cottage system, not in the form of military barracks.[19]

In both types, the expectance is an organic relationship with the university and the city, however, the outcome has always been a form of mutual exclusion, which limited the contact between the university and the city physically occur at the campus gates only. The campus gates in Turkey have been considered solely as surfaces for passage, and designed accordingly, while it is possible to imagine them as peripheral organs. The only concern about the university gates how it looks when it is observed from the city, and how it would represent the identity of the university.

It is also necessary to review how "gate" has been read as a cultural code. From Seljukian period on, "gate" has always been a means of magnificence and show off. In Pakalın's paper, the Ottoman uses of the Arabic word for gate, i.e. "bab", in noun phrases are explored in order to show the variety of symbols the word has been related: Bâb-ı-âli (The grand gate), Bâbu'ssaâde (the gate of felicity), Bâb-ı Hümâyun (imperial gate), Bâbu'sselâm (the gate of welcoming), Bâb-ı şerif (the gate of Mevlana's tomb), Bâb-hükümet (the gate of the government), Bâb-ı devlet (the gate of the state), Bâb-ı fetva (the gate of the grand judge), Bâb-ı seraskeî (the gate of military), Bâb-ı ı ahiret (the gate of the afterlife), Bâb-ı selâmet (the gate of salvation), Bâb-ı cihad (the gate of war), Bâb-ı ül ebvap (the gate of the gates), Bâb-ı ullah (the gate of god), Bâb mahkemesi (the gate of the court), Bâb-ı inayet (the gate of mercy)[21] The border gates separating the neighboring countries from each other, the city gates that serve as the entrance to cities, the gates of the middle age castles with drawbridges, fully ornamented crown gates of historical buildings, ceremonial gates of the governors with military guards, the gates located on the holy routes of the temples, victory gates after wars are all the examples which have symbolic values besides their functions, and they add up to the concept of gate in the culture.[22] The famous ceremonial gates of the Topkapı Palace are greatly valuable in this sense.

The university as a symbol of education and knowledge seems to have isolated itself from the outer world by the use of its gate. In our country, the seminal example might be the gate of Beyazıt Campus of İstanbul University as a significant architectural image. This campus had been used as a military campus, and the gate was built in 1827 in a different from than its recent form. Its present form was built in 1864. After İstanbul University was established, the gate became the unique element of identity representation for the university. In most of the discussions on universities, science and education, the front façade of the gate facing Beyazıt Square, i.e. its face towards the city, has been used as an image. This may be one of the reasons why universities made use of their gates facing the cities as their representations traditionally.

4. Gates of Universities in Turkey as Tools of Identity Representation

Besides their basic function, i.e. as passages between the city and the campus, and as an interface, the university gates have been used to construct their identity. Universities designed their gates considering the characteristics of the cities they are located in, their institutional characteristics, and the geographical characteristics of their region; and the way the city would perceive them has been a crucial concern in the designs of these gates. The examples in this paper are not chosen in a chronological order. The university gates bearing similar characteristics are grouped and categorized according to the revealing concepts. The resulting picture shows that many gate designs had similar concerns, although identity emphasizes uniqueness. It should be noted that there are many aspects in design and construction processes of these gates that we cannot discuss here in the limits of this paper, such as the costs, administrative problems, qualified designers and so on. In the scope of this paper, the aim was to sketch out a general panorama.

The motivations of the universities in Turkey while designing their gates as identity representation tools are categorized into four groups:

(1) Local references

(2) Free-floating historicity

(3) Geometric / Stylistic Experiments

(4) Place/ ments: Spatialized Gates

These sub-topics were generated by discussing the similarities of the grouping samples. These similarities are; common architectural elements, structural aspects, symbolic references and relationship with context. Aesthetic judgment was avoided, and an objective perspective was attempted.

4.1 Local References

The parallelism between the identity of the city and that of university was often observed in the examples. Especially the universities established in Anatolia designed their gates with obvious direct or transformed references to the identity of the city they are located in.

Figure 1. The Gate of Adıyaman University and the Cendere Bridge in Adıyaman

Usually, the architectural objects in the cultural heritage of the related city were analogically transformed into a gate, and the outcome had an effect that the observer enters into an institution which is a continuous part of the city.

Figure 2. The Gate of the Harran University and Historical Houses of Harran

Figure 3. The Gate of Recep Tayyiip Erdoğan University and Historical Houses of Rize

As can be seen in the images above, some formal characteristics or architectural details in the historical textures of the cities were either directly copied or transformed, with an aim of material and formal similarity.

Figure 4. University of Ahi Evran and Cacabey Mosque in Kırşehir

From these preferences in the representation, it may be claimed that these universities as educational institutions relate knowledge with locality, and seek their identity in their roots. However, since they either copied or directly used the local forms, their perspective seems to be formalist and two dimensional. In some examples, the forms of gates present in the historical texture were used in an updated design, and the outcomes were far-fetched formal contradictions.

4.2 Free-floating Historicity

Another common tendency observed in the examples is the use of total historicism as a perspective to relate with the local. These universities, rather than making use of local historical images, designed their gates as historical collages in which forms, ornamentations, and organizations were used to refer to historicity in general. Rather than clear local references to a place or to a city, a monumental effect was aimed, similar to that of the gate of İstanbul University.

Figure 5. The Gate of Altınkoza University

Figure 6. The Gate of Kütahya Dumlupınar University

Some examples formally represent an artificial historicity while they also attempt to integrate the place by their spatial positioning in the city.

Figure 7. The Gate of the International Antalya University

Figure 8. The Gate of Konya Selçuk University

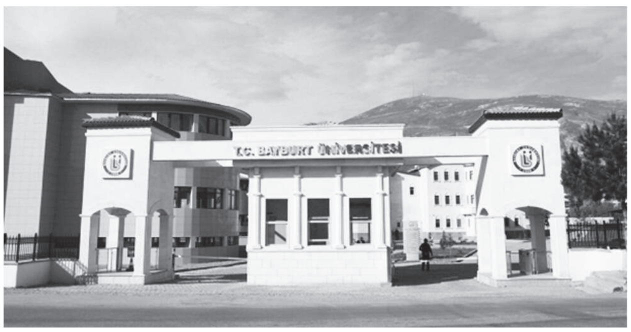

Figure 9. The Gate of Bayburt University

Considering the fact that the most of the examples in this category are recently established universities, the concept "free-floating historicity" is used to explore how they attribute an artificial set of roots, history and historicity to their identity. While they construct their identity in the cities they are located, they make use of images and ornamentations regardless of the historical or geographical source of them. The outcomes turn out to be obvious examples of lack of identity. In any of these examples, one can change any historical element with another one from an entirely different period, and the result would not change at all. While these institutions seem to have an identity construction strategy to appear as a well-rooted institution, the results are the opposite.

4.3 Geometric / Stylistic Experiments

Another strategy in identity representation by campus gates is to produce the gates as images independent of the characteristics of the place and the city, without any historical connection, just using the recent building methods. There are many examples in this category. While some of them attempt unique formal experiments in order to construct a catchy representation, some others simply employ repeating basic geometric forms.

4.3.1 Rational Objects

The examples in this category are mostly in Anatolia. The gates pragmatically separate the functions of pedestrian passages and vehicle passages, and employ fringes to remark the gate. The forms used include primal geometric shapes in a non-contextual fashion. These examples simply use names and logos of the university to represent the identity of the institution.

Figure 10. The Gate of Ağrı İbrahim Çeçen University

Figure 11. The Gate of Bingöl Univesity

Figure 12. The Gate of Canik Başarı University

Figure 13. The Gate of Melikşah University

As can be seen in these examples, these gates are used as vistas that remark the spot of entrance. In most of them, horizontal and vertical forms are combined in clear geometric relations. These examples can be considered as the most diffident ones in terms of identity representation.

Figure 14. The Gate of Avrasya University

4.3.2 Formal Quests

A part of the gates, which are designed independent from the city and the history attempt to reconstruct the perception of the university by employing new forms. The present context is generally ignored, and the gates become attention-grabbing autonomous architectural objects. Some universities used their corporate logos as the point of departure for the spatial design of the gates. This attempt seems to aim at sustaining the corporate identity.

Figure 15. The Gate of Gümüşhane University

Figure 16. The Gate of Muğla University

What is common in this category is the variety of materials and colours. A further study would show whether the local materials were used in the construction of these gates or not. Considering their existence in the city, the aim of the gates in this category seems to be abstraction, non-contextuality, and production of an attention-grabbing image.

Figure 17. The Gate of Nevşehir University

Figure 18. The Gate of Karabük University

Figure 19. The Gate of Süleyman Demirel University

4.4 Place/ment: Spatialized Gates

Some of the examples in this research manage to transform their relation with the city to an architectural and spatial formation. In these examples, in contrast with all the above, the gates are not considered as two-dimensional passage surfaces and the representation of institutional identity is not designed as surface graphics. The function of entrance in these examples, expand into a spatialized design. Especially in the award-winning projects in the national architecture competition for the gate of Davutpaşa Campus of Yıldız Technical University, the relationship of the gates with their place and the city makes them much more than simple passages.

Another common point in all these projects is that the project images depict an expansive, dynamic and wider entrance processes while all of them became much simpler when they were built. This means that in theory some attempts exist to enhance the relations between the city and the university, however practically the old tendencies overcome these attempts.

Figure 20. The Digital Image from the Project of the Gate of Ordu University

Figure 21. Project for the Gate of Çankırı Karatekin University

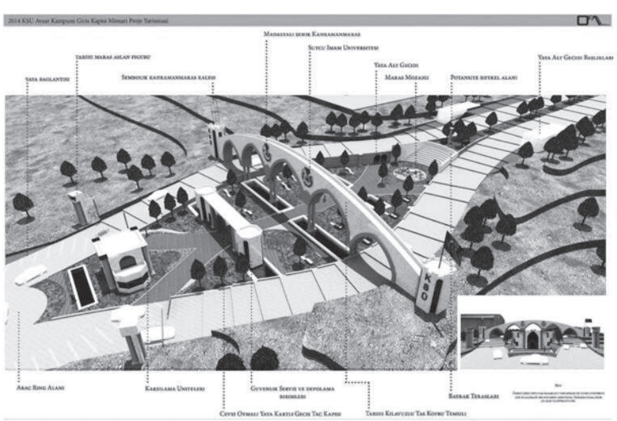

Figure 22. The Project Proposal for the Gate of Sütçü İmam University

As in other examples, some university gates mind about their location, and attempt to reorganize and redefine that place spatially with their existence. Some of them are located at the border with the city, and they open new spaces for city functions, while the structures of some others make their surroundings more defined environments. The award-wining projects of the competitions mentioned above all had similar concerns, and they attempted to transform their place rather than being a solely visual representation of the university. These gates, formed by an expansion of the fringe and belonging to neither the university nor the city, can be imagined as the potential starting point of the idealized relationship between the university and the city. These spaces have the potential to organize the identity of the related institution.

Figure 23. The Gate of Pamukkale University

Figure 24. The Gate of Uludağ University

Figure 25. The Gate of Abdullah Gül University

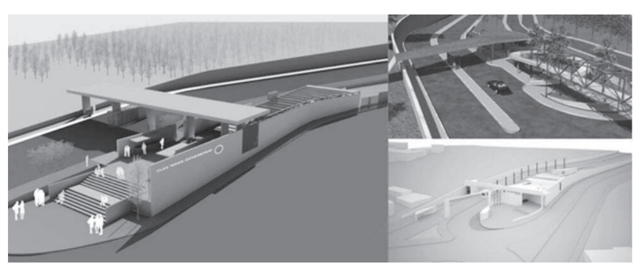

Figure 26. Award Winning Projects in the Competition for the Gate of Davutpaşa Campus, Yıldız Technical University

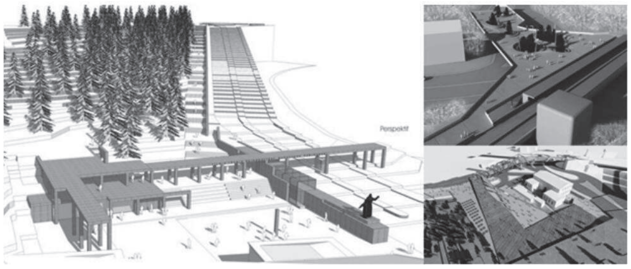

Figure 27. Award Winning Projects in the Competition for the Gate of Davutpaşa Campus, Yıldız Technical University

5. Conclusion

All the examples analysed in this paper, and the ones which were included in an initial categorization show that universities in Turkey attach importance to their gates since the gate is the very spot where the tension and interaction between the city and the university takes place. The gate is also the platform on which the institutional identity representation, integration to the city and seeking for a privileged position continue and become materialized. With the use of various methods and intentions, almost all university gates become important because of their function of facing the city; hence their design and construction are elaborated. In most of the examples, campus gates are not considered as architectural elements, their potential not realized, so that they remain as simple intersections of passage. The infertile connection between the city and the university is sustained in these examples which could not manage to be spatialized. Universities are not completely independent of the cities they locate in, and their basic function should be to produce and spread information and knowledge. This is the reason why the architectural problem of the campus gate should be questioned further, so that universities would be able to produce them as new spaces of interaction with the city rather than sole identity representation tools.

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3 C's of Architectural Space

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Abstract: Architectural space has mainly two forms: spatial and corporeal. Within this context, the main purpose of the study is re-theming and interpreting the new connections within these two forms of architectural space by the help of three concepts; Conciseness, Continuity and Compatibility, called as the 3C`s of Architectural Space. The subjects of these three are presented as an open system in order to extract transferable ideas for re-theming the meaning of space. These concepts are evaluated with their reality in built forms through on-site observation inside the selected buildings. This study approaches architectural space clarifying the relevance of design elements and providing a reference framework for them.

Keywords: Architectural space; Conciseness; Continuity; Compatibility

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1. Introduction

Apart from its sheltering function, architecture acts in its own way as a mediator and horizon within the human living environment. It enables people to locate and orientate themselves and also it has mental and physiological foundations and associations (Buchert, 2014: 46). Michael Hays (2010:12) examines architecture as a way of negotiating the real, by intervening in the realm of symbols and signifying process at the limit of the social order itself. Architecture is also a specific kind of socially symbolic production whose primary task is the construction of concepts. Architecture that is always charged with the task of shaping the human habitat and has a fundamental influence on people's daily physical environment has different possibilities than the fine arts due to its degree of freedom and its constructive and technical restrictions. (Buchert, 2014 , p. 46). Space, as the medium of all these interactions, is created by natural and artificial settings that architecture involved in this process.

Beginning from Plato and Aristotle, there are so many definitions and studies on the meaning of space. The nature of the relation between architecture and space raises a number of philosophical questions in diverse disciplines like, perception (Pallasmaa, 2005; Edward, 1990), phenomenology (Merleau-Ponty, 2004; Heidegger, 1993; Bachelard, 1964) methodology (Buchert, 2013). Heidegger (1993: 358) defines space, as it is neither an external nor an inner experience; it is not something predetermined and fixed. On the other hand, Lefebvre (1998) defines space as a social product and hypothesized that `day-to-day` life is itself alienated that it is through daily life in particular that social relationships are reproduced. (Cited in Busquet & Lavue, 2013:2). Research on architectural space often merges of with that of place. According to Tuan, (2001) the ideas "space" and "place" require each other for definition. Author particularly states that `from the security and stability of place we are aware of the openness, freedom, and threat of space, and vice versa... Moreover, while space is an open and abstract area, place is deliberated as a location, a part of space achieves its particular identity through the factors inside it. (Parsaee, Parva & Karimi, 2015,p. 370).

Architectural space, it's meaning as a part of architectural design; principles and values are the main concern of this study. Architectural space has two forms: spatial and corporeal, and space is the integrated entity of all these two forms. In this way, the main purpose of the study is re-theming and interpreting the new connections within these two forms of architectural space by the help of three concepts; Conciseness, Continuity and Compatibility, called as the 3C`S of Architectural Space. These three concepts are considered as the integrated concepts for analyzing the meaning of architectural space. The subjects of these three are presented as an open and atypical system in order to extract transferable ideas for re-theming the meaning of space. These concepts are evaluated with their reality in built forms through on-site observation inside the selected buildings. This study approaches architectural space clarifying the relevance of design elements and providing a reference framework for them.

2. 3C'S of Architectural Space

"Architecture is 'art' when the design of space is clearly takes precedence over the design of the objects. Spatial intention is the living soul of architectural creation."

——August Schmarsow, 1897; Cited in (Meiss, 2013, p. 130)

As the core of architecture, space is about everything related to the life itself. It is the crucial part of a very fundamental and universal form of communication. (Lawson, 2001, p. 6) In particular in this study the main concern about space is that it is an entity that is created in and around architecture. For Lawson (2001:6) architecture manages space, and its interiors and the objects covering and inhabiting its rooms can enable or inhibit our activities. Spatial form of space is defined by the influence of social practices, sociality, and also the contextual surrounding, as historicality. (Grobler & Le Roux,2006). This dimension also covers the idea of perception, sense and experience. Additionally, corporeal form of space is not just to structure the topology of the design form, but also rather to give it a coherent and intelligible form. It carries this function by operating within the context of a symbolic system (Bafna, 2005). Moreover consideration of corporeal form in building is not merely a matter of giving visual shape and meaning to buildings, but is central to the making and understanding of spatial form as well`.(Bafna, 2003) . The term also deals with the visual elements like, shape, color, texture, and size.

In this study the architectural space is discussed through these two basic forms of space by utilizing three concepts; Conciseness, Continuity and Compatibility; as a whole and overarching architectural space analyses. These three concepts called as 3C's of Architectural Space, which are considered as the integrated structure for analyzing the meaning of architectural space. They proposed as the key concepts in defining the essence of space not only as a building envelope, but also as a sociological, cultural and ideological entity that are all considered as the main features of spatial and corporeal form of space. The first concept Conciseness is about the quality of being clear and understandable that reflects the clarity and lightness of the space. The second concept Continuity is mainly about the connection of the objects, actions that have a proximity or similarity in space. Term covers integrity and movement. Compatibility is about integration of the design form with its physical settings considering the ideological and historical values, principles. The concept covers the terms; harmony, ensemble and palimpsest.

3. Conciseness

The term conciseness is about the quality of being clear and easy to understand: clarity, intelligibility, (Macmillian dictionary, 2018). ① This term has chosen for to state the essence of use and form, clarity, lightness, openness, accessibility, simplicity and transparency. The term refers to program, function, atmosphere, but also about the meaning of the architectural solution. Moreover, the concept is also about integration of the reality in the abstraction of the form. Günter Behnisch Vogelsang Elementary School in Stuttgart/ Germany is an example, as it is the expression of purity and clarity of material and tectonic expression that the expression of this absence creates a quiet impressive feeling. (Picture 1). The simplicity of construction, clarity of material and spatial emptiness is quiet stimulating. It also conveys plural beauty, with simple geometric shapes and demonstrates that simple can be beautiful. A building is simple not because its shapes conform to elementary geometry, not because all of it is immediately visible, or because the logic is evident in its connections.

Figure 1. The Main Entrance (photo on the right) and Entrance Hall from inside (photo on the left) of Vogelsang Elementary School, Stuttgart Germany, Architect: Günter Behnisch, 1961 (Source: Author's achieve, 2017)

The concept conciseness is also related to the transparency that is variously attributed to material properties: the literally 'see through' capacity of glass; the necessary structural condition for democratic systems; and positions of intellectual and philosophical engagement (Wainwright, 2011, p. 32),. Transparency also brings to the fore the systems and structures of spatial, political and cultural organization which form an invisible base supporting the idea of democratic cultures. According to Forty (2000: 286) literal transparency; meaning to light, allowing one to see into or through a building, was made possible by the development of frame construction and techniques for fixing large areas of glass. Phenomenal transparency; implies more than an optical characteristic, it implies a broader spatial order.(Forty, 2000, p. 287). Besides these two features; transparency approved as a structural condition for democratic systems and positions of intellectual and philosophical engagement. (Wainwright, 2011, p. 32).

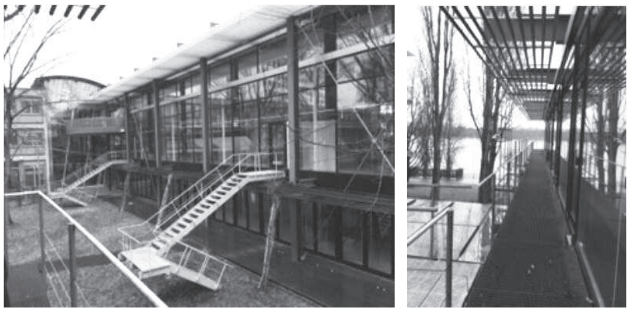

Figure 2. Plenary Chambers, Bonn, Germany, Architect: Günter Behnisch (Source: Author`s Archive, 2017)

As the symbol of democratic architecture Günter Behnisch use transparency as the principal of his architectural analogy. He do so because the ideological thinking supporting transparency posits the new architecture as the antithesis of historic state buildings the embodiment of democratic values, and the symbol of the open society. (Barnstone, 2006) (Picture 2) His transparency is a metaphor for the desired condition, as in political discourse where it is equated with openness, accessibility, and pluralism.

4. Continuity

Continuity is an uninterrupted connection, succession, or union (Merriam-webster dictionary,2018). [2] The term refers to the connection of the objects, actions that have a proximity or similarity in space. A spatial continuity is about creating a sequence of motion systems, connection points, and spatial relations making the promotion and modifications in the metaconscious sense of order possible (Ardalan & Bakhtiar, 1973). Additionally, continuity is a principle that structures the reading of spaces that make it to construct a coherent and continuous mental image of the world and the situation. (Vinot & Conversy, 2015). Moreover, Sözmener (2012: 41) states that objects in space couldn't design independently from another, whether fixed or portable, moreover relationship between in each other should be forefront. Elements that setup the structure (walls, floors, columns, beams, etc.) have to be parts that complete each other, not parts that coupled each other. The continuity of these elements from the interior to exterior and exterior to interior, expanding the detection limit of space and create integrity between interior and exterior. Accordingly Vinot & Conversy (2015) declares that, the idea of continuity refers to a subject's ability to "link" objects, actions or events that exhibit a proximity or similarity in space or in time, to make it the parts of a whole.

Phaeno Science Center, Wolfsburg , in Germany is an

Figure 3. Phaeno Science Center, Wolfsburg, Germany, Architect: Zaha Hadid (Source: Author's Archieve, 2017)

example to the continuity ,where circulation is stimulated by free space between the stanchions, as well as by the dynamic pointed form of the building (Buchert, 2013, p. 142). The interior space is a continuous formation with platforms, countered and inclined adjoining level formations for an overall spatial constellation, allowing people to move freely. (Buchert, 2013, p. 142). Here continuity refers to the fluidity of the design form that is integrated with the movement and links in the space. Movement through the building is a way of organizing one's experience of it, of orienting the body in relationship to something outside of itself. And also movement through the space is offering a discrete scheme that creates a dialogue and connection with a particular context.

5. Compatibility

Compatibility is the capable of existing together in harmony`. (Merriam-Webster dictionary,2018). [3] The concept is about integration of the design form with its physical settings considering the ideological and historical values, principles. The term refers to harmony, ensemble and palimpsest in spatial and corporeal form of the building. The term ensemble comes from French word―ensemble and it means ―mutually harmonious composition (Bahronovich, 2015, p. 109). Olympic stadium in Munich is an example of an architectural space that has an excellent integration, ensemble between natural environment and the design structure itself. Lin (1989) asserts that in Behnisch's work (Olympic Park), the continuous built-up roof exaggeratedly shelters a recreational area. This led to the idea of creating an atmosphere of openness, clarity and ensemble. The design idea was developed to embed the buildings in the landscape (Picture 4) . The aim was not individual buildings, but an architectural landscape that covers different forms of use. (Eckart, 2016, p. 149). Moreover the facility offers a closed appearance and be closely interwoven with the urban fabric: the urban functions coming from outside - green corridors, waterways, roads, footpaths, cycle paths

- are grasped and intensified in the terrain. The powerful movement of the existing hill is absorbed and guided through the area as a defining, three-dimensional form. (Eckart, 2016, p. 150).

Figure 4. Olympic Stadium, Munich, Germany Architect: Günter Behnisch (Source: Author's Achieve, 2017)

Compatibility of space is also about connecting the past, present and future of the building itself being as a socio-cultural entity. As the powerful idea of compatibility, palimpsest is about an ongoing process of rewriting through time, thus linking the past with the present and future. Particularly in the contemporary architecture the idea of palimpsest becomes important for designers because it works throughout all scale levels. "Regarding buildings as palimpsest implies to read them as processes." (Verheij, 2015, p. 20).

Sandler (2016: 105) declares that the theme palimpsest is related to but identical to the concept of multi-layering. It is a constant process of erasure and rewriting scraping, and reinscription. Palimpsest was used in the works of the architects such as Daniel Libeskind, Zaha Hadid that interpreted at field of architecture including social, historical, and physical ground. This group of architects believed in context, which is living, and dynamic entity with unique ability to record the events that could have acted like continuation of peripheral memory (Rapoport, 1982; cited in Arbabiyazdi & Pisheh, 2012: 1634). Having a sophisticated coincide with the roles of museum, monument and memorial, Jewish Museum has contemplation on the museum's role in both representing and covering memory. (Stead, 2000, p. 2) (Picture.5) . Libeskind expresses the purpose of the museum as below;

"The museum attempts to give voice to a common fate: common to both what is being and what are other than being. The museum must not only inspire poetry, music, drama, etc. but also give home to the contradictions of the ordered/ disordered, the chosen/ unchosen, and the welcome / unwelcome the vocal / silent. In this sense the particular urban condition becomes the spiritual site wherein the nexus of Berlin's destiny is at once mirrored, fractured and transformed". (Libeskind, 1990, p. 48)

Libeskind calls the project 'Between the Lines', which is the expression of two intersecting 'lines'. These lines signifying German and Jewish histories that are integrated within. (Libeskind, 1990). As the building has a multi-layered structure, it has an intention to link the past and present by the means to construct a bridge through the time with its fractured and transformed entity. Briefly, the building has a strong discourse reflects how landscapes, buildings and objects are layered through the passage of time. It makes us aware of the integration of many different layers with its spatial and corporeal feature.

Figure 5. Jewish Museum, Berlin, Germany, Architect: Daniel Libeskind (Source: Author`s Archive, 2017)

6. Conclusion

This study is an attempt for reconsidering the meaning of architectural space where it is interpreted by three new concepts: Conciseness, Continuity and Compatibility. The reason for developing these three concepts is about remedying the deficiency in literature on architectural space that is mostly concerning the particular facets of the space. By the contents and intentions of these three concepts, architectural space could be interpreted as a whole structure that covers all two main dimensions of architectural space as spatial and corporeal form. Through the help of these key concepts, the essence of space is discussed not only as a building envelope, but also as a sociological, cultural and ideological object that are all considered as the main features of the architectural space. More importantly, these conceptions assessed the design as a form of associated ideas of the work as a vigorous commodity.

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Annotation

① https://www.macmillandictionary.com/dictionary/british/concise?q=Conciseness#concise_4, Accessed May 28,2018

② https://www.merriam-webster.com/dictionary/conciseness, Accessed May 28,2018

③ https://www.merriam-webster.com/dictionary/compatibility, Accessed May 28,2018

Frontiers Research of Architecture and Engineering

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Trial registration: Name of trial registry (Trial Registration Number)

Contribution: Researchers A and B researched literature and conceived the study. Researcher A was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. Researcher B wrote the first draft of the manuscript. All authors reviewed and edited the manuscript, and approved the final version of the manuscript.

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VII. Introduction

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