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Editorial

Symmetry in Safety and Disaster Prevention Engineering

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Introduction

Due to the in-depth, yet incomplete, research on urban construction in many cities and towns, and the lack of considerations of symmetry, the rapid development of urban construction has led to a variety of urban disasters. The types, quantity and scope of urban disasters are increasing, and so it is necessary to end the practice in urban construction of only paying attention to the speed and scale of development, while ignoring symmetry during the development process. Safety and disaster prevention engineering concerns diverse critical perspectives on all dimensions of engineering disasters. The rapid development of safety and disaster prevention stimulates innovation in emerging strategic industries, and reduces the loss from various disasters. Symmetry is frequently used in safety and disaster prevention engineering, for example, in model construction and civil engineering.

In this Special Issue of *Symmetry*, invited researchers elaborate on the application of symmetry in various aspects of safety and disaster prevention engineering, including, but not limited to, seismic engineering structures research; wind engineering and structural safety research; structural health monitoring and safety evaluation; disaster prevention mechanisms; disaster management system architecture; structure safety analysis methods; materials, bridges, rock–soil, municipal, and water conservancy; and diagnosis technology, etc.

In this Issue, Wei et al. [1] propose a new deformation monitoring method for a symmetrical tunnel structure based on 3D laser scanning technology. Initially, 3D laser scanning was used to obtain scattered clouds of irregular structures considering the New Austrian Tunneling Method (NATM). Afterwards, modified B-spline interpolation and greedy triangulation were used to fit the surfaces. Moreover, the normal vector matrix was innovatively applied to express the deformation of the tunnel fitting surface, which solved the problem of scattered point clouds in 3D laser scanning. A normal vector was obtained by the intersection of the normal of one fitted surface with the other. Subsequently, the maximum entropy method was introduced to form the probability density function of the normal vector, and the 1% and 5% probability eigenvalues were used to analyze the overall deformation trend of the tunnel. Finally, the eigenvalue of 5% probability, which was less affected by construction uncertainties, was selected for analysis. In this way, an analysis and prediction method for overall tunnel deformation was established.

Yang et al. [2] established a new indirect approach to identify the stiffness of symmetric girder bridge elements to detect the deflection of the bridge. Two identical vehicles stayed at rest at the designated measurement points and their vertical accelerations were collected. After one measurement, the two vehicles moved to other designated measurement points and the accelerations were collected again. The same procedure was repeated until the two vehicles had moved over all the designated measurement points. Then, the blind source separation technique was employed to extract the fundamental mode shape of the bridge and the improved direct stiffness method was adopted to estimate the bridge element stiffness based on the collected data, which are used to monitor the health of the bridge structure and to maintain structure safety and natural symmetry. The proposed method only requires the output response of the vehicle due to the involvement of the blind

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Citation: Yang, Y. Symmetry in Safety and Disaster Prevention Engineering. *Symmetry* **2023**, *15*, 2101. https://doi.org/10.3390/sym15122101

Received: 28 February 2023
Accepted: 30 May 2023
Published: 23 November 2023

separation technique. In addition, the proposed method can overcome the adverse effect of road surface roughness, because the vehicles only move between two measurements and they stay at rest during one measurement.

Liu et al. [3] studied a class of hybrid isolation systems constructed by combining Buckling Restrained Braces (BRBs) with Rubber Bearings (RBs) or Lead Rubber Bearings (LRBs) for mitigating the seismic responses in bearing-supported bridges during strong earthquakes. Firstly, two different hybrid isolation systems (RB-BRB and LRB-BRB) were preliminarily designed based on the energy conservation concept in the case of a bridge with Y-shaped piers, which can meet all the energy demands at different seismic hazard levels. Furthermore, seismic evaluations were conducted on the bridges with the LRB, RB-BRB, and LRB-BRB isolation systems based on nonlinear time history analyses. Finally, based on fragility analyses, the effects of the gap spacing and the stiffness ratio of the BRB to the pier were investigated with respect to the failure probability in the case of a bridge with LRB-BRB.

Xing et al. [4] found a novel nonparametric approach for detecting early signs of structural deterioration in civil infrastructure systems from vast field monitoring datasets. The process adopted a six-sample sliding window at one-hour time increments to overcome the fact that the sampling times were not precisely consistent at all monitoring points. After processing data using this method, the eigenvalues and eigenvectors were obtained for each moving window, and then an evaluation index was constructed. Monitored tunnel data were analyzed using the proposed method. The required information extracted from an individual moving window was represented by a set of principal components, which became the new orthogonal variables. The resulting evaluation indicator was strongly correlated with measured and calculated values up to 0.89, even for tiny monitoring datasets.

Li et al. [5] have deeply researched the flutter derivative prediction of flat steel box girders based on CFD simulations. Firstly, by taking the flat steel girder section of Qingshan Yangtze River Bridge as the basic section and considering its width and height as the design variables of cross-section shape, the design domain of the cross-section shape was defined by controlling the possible range of variation in cross-section design variables. A small number of cross-sections were selected for the calculation of aerodynamic forces using CFD simulations. Secondly, the flutter derivatives are identified by the least square method according to the aerodynamic lift and moment time-histories of these steel box girders. Next, Kriging models were trained using the selected cross-section shape design parameters as inputs, and the flutter derivatives obtained from CFD simulations as outputs. To improve the prediction accuracy of Kriging models, a modified method of model training is presented. Finally, the flutter derivatives of other cross-sections in the design domain were predicted by using the trained Kriging models, and the predicted flutter derivatives were verified using CFD simulations.

Zhu et al. [6] focused on the environmental effect and corresponding mechanical properties of the construction process of symmetrical beam string structures. A method for capturing key components and an intelligent safety analysis of beam string structures based on digital twins (DTs) was proposed. Driven by the twin framework, multi-source data for structural safety analysis were obtained and the parameter association mechanism established. Considering the space–time evolution and the interaction between the virtual and real elements of the construction process, a multidimensional model was established. The safety of the structure was analyzed intelligently by capturing key structural components, thereby providing a basis for the safety maintenance of the structure. The integration of DT modeling and multi-source data improves the accuracy and intelligence of structural construction safety analysis. The core step in the analysis process is capturing the key components of the structure. They then applied the outlined research method to the example of the construction process of a string-supported beam roof (a symmetrical structure) in a convention and exhibition center. Based on DTs and D-S evidence theory, the degree of variation in mechanical parameters of various components under temperature was determined.

Fu et al. [7] introduce a new type of on-site non-destructive testing instrument for measuring the impermeability of symmetrical walls. The research and development of this instrument is based on the water drenching method. The influence of symmetry is mainly considered in the design process, and it has on-site testing functions such as water pressure adjustment and wind pressure simulation. The water seepage of the four types of masonry walls under the combined working conditions of three levels of spray strength and wind pressure strength was tested by using instruments. The results show that the junction of mortar joints is a weak location regarding the impermeability of the masonry wall. Parameters such as wall leakage time, seepage area, and water seepage amount are significantly affected by wind pressure. Furthermore, during on-site inspection, the influence of wind pressure on water seepage conditions must be considered when simulating the real wind-driven rain conditions.

Zhang et al. [8] implemented a new method for analyzing the shallow slope stability in symmetrical expansive soil, based on the coupling effect of saturation and expansion. With the described coupling effect and an infinite slope, they established a formula calculating the overlying load of the shallow soil using the symmetrical limited expansion along the slope and perpendicular to the plane. Moreover, a model for calculating the factor of safety is presented according to the limit equilibrium method. The experiments are designed to demonstrate the feasibility and effectiveness of the proposed analysis method for the shallow stability of newly excavated and newly filled expansive soil slopes under rainfall. The study investigated the moisture content and shear strength of the shallow expansive soil slope, and calculated the factor of safety.

Gao et al. [9] discuss jumps on bridges caused by vehicles passing over a damaged expansion joint. The traditional dynamic amplification factor defined by the current bridge design code shows the amplification of the static effects on the bridge. However, it only concerns the stable moving load induced by the vehicle. The sudden vehicle impact due to a damaged expansion joint sometimes exceeds the allowable design load, so it is important to evaluate the dynamic impact in practice. In fact, the dynamic impact can be approximately considered as a contact force between a damped harmonic oscillator and a beam due to the bilateral symmetry of the vehicle; therefore, a model-based approach using the bridge midspan acceleration is proposed in this study to approximate the impact force, where it is assumed to be an exponentially damped sine function. This is a typical parametric model-based inverse problem. The conjugate direction method is used to determine the unknown parameters and the initial values are determined by a simple global search method.

Ren et al. [10] explored the operational data of wind power systems. They propose an improved K-means weighted dynamic clustering fault classification algorithm (DT clustering) with the aim of solving problems arising from the low efficiency and low accuracy of fault classification of wind power towers and turbine equipment (referred to as wind power systems for short) using artificial data analysis. First, historical and asymmetrical operational data from wind power systems were pre-processed to construct the data time series matrix and establish the fault classification model; second, the linear approximate constrained optimization algorithm and multiple regression algorithm were combined to build the model parameter optimization model. Finally, the comparative analysis of various algorithms showed the superiority of this algorithm.

Finally, this volume will be of interest to civil engineering researchers and engineers specializing in safety and disaster prevention engineering theory, method, technique, and beyond. Many of the results presented here can be very useful for demonstrating new results.

Funding: The research was funded by the Innovation Group Project of the National Natural Science Foundation of China (52221002) and Fundamental Research Funds for the Central Universities of China (2022CDJQY-009).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

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