Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2023.29431

290 (2023) 226–231
April

Automatic monitoring technology of salt spray corrosion of steel structure in coastal building construction

Laiyun Lu[a,*], Yang Li[a], Pengfei Ni[a], Haixing Lin[a], Xiaoli Ma[b]

[a]*CSCEC 7th Division, Installation Engineering Co., Ltd., Zhengzhou 450000, China, email: lulaiyun311@163.com*
[b]*School of Engineering and Computer Science, University of Hull, Hull HU67RX, UK*

Received 27 April 2022; Accepted 15 July 2022

ABSTRACT

In order to improve the salt spray corrosion resistance of steel structure in seaside construction, reinforced concrete is used to design steel structure in seaside construction. Based on the analysis of yield strain characteristics, an automatic monitoring method of salt spray corrosion of steel structure in seaside construction is put forward, and the prestress characteristic analysis model of reinforced concrete is established. The characteristic parameter estimation method of shear capacity is used to analyze the salt fog corrosion resistance of steel structure concrete in seaside building construction, and the vertical deflection characteristic quantity of steel structure in seaside construction is extracted. through the method of steel bar strain measurement and plate angle binding measurement, the tensile force test of reinforced concrete is carried out, and the strain difference of steel structure in seaside construction is analyzed quantitatively. Under the dual action of steel and concrete, the salt spray corrosion resistance of steel structure in seaside construction is improved. The test results show that the salt fog corrosion resistance of steel structure design in seaside building construction is better, the yield strain ability of reinforced concrete is enhanced, and the resistance stiffness of steel structure in seaside building construction is improved.

Keywords: Seaside construction; Steel structure; Salt spray corrosion; Automatic monitoring.

1. Introduction

In the construction process of seaside buildings, due to the corrosion of seawater, the corrosion resistance of concrete materials to salt fog corrosion is very high. It is necessary to analyze the anti-salt fog corrosion resistance ability of steel structures in seaside construction. Combined with the prediction and optimization control methods of salt fog corrosion resistance of steel structures in seaside construction, the optimal design of seaside building concrete is carried out [1]. The application of reinforced concrete in salt spray corrosion resistance of steel structures in seaside construction is studied. the prediction and control method of salt fog corrosion resistance of steel structures in seaside construction is based on the analysis of tensile mechanical parameters between steel bars and concrete slabs [2,3]. Combined with corrosion prediction control of interface contact slip distribution, the salt spray corrosion resistance of seaside building concrete is improved. Through the analysis method of negative bending moment characteristics of continuous composite concrete structure, the optimal configuration of reinforced concrete is carried out, and applied to the study of salt fog corrosion resistance of steel structure in seaside construction. Through the tensile stress test of concrete slabs, the salt fog corrosion resistance analysis method of steel structure in seaside construction has attracted great attention [4].

Traditionally, the test method of salt spray corrosion resistance of steel structure in seaside construction is mainly based on fuzzy prediction method. Combined with the superposition analysis method of negative moment zone of

* Corresponding author.

steel structure in seaside construction, the corrosion resistance of steel structure to salt fog is controlled in the construction of seaside building [5]. The design method of salt fog corrosion resistance of steel structure in seaside building construction based on continuous composite beam structure test is put forward by Yu and Lv [6], and the salt fog corrosion resistance control of steel structure in seaside building construction is carried out combined with the reaction force test of internal support, but the output stability of salt fog corrosion resistance control of steel structure in seaside building construction is not good. A test method for salt spray corrosion resistance of steel structures in seaside construction based on the analysis of double-sided combined stress characteristics is put forward by Lin et al. [7]. The stress analysis of tensile concrete and steel beam elements is carried out to improve the output control ability of salt fog corrosion resistance of steel structures in seaside construction, but the salt spray corrosion resistance of this method under uniform load conditions is not good [8,9].

In order to solve the problems, this paper puts forward a predictive control method for salt spray corrosion resistance of steel structures in seaside construction based on vertical load analysis, tests the tensile resistance of reinforced concrete, makes quantitative regression analysis on the strain difference of steel structures in seaside construction, and improves the salt spray corrosion resistance of steel structures in seaside construction under the dual action of steel and concrete [10,11]. Finally, the experimental test and analysis are carried out, and the conclusion of effectiveness is obtained.

2. Mechanical parameters of salt spray corrosion resistance of steel structures in seaside construction

2.1. Pre-stressed characteristic analysis model

In order to realize the application of reinforced concrete in salt spray corrosion resistance of steel structure in seaside construction, the prestress characteristic analysis model of reinforced concrete is established, the characteristic parameter estimation method of shear capacity is used to analyze the salt spray corrosion resistance characteristics of steel structure concrete in seaside construction, and the evaluation parameters of salt spray corrosion resistance of steel structure reinforced concrete in seaside construction are initialized [12]. Combined with the analysis method of concrete floor and shear connector assembly, the distribution parameters of concrete tensile strength are $F(x_i, A_j(L))$, $i = 1,2,\ldots,m$, $j = 1,2,\ldots,k$, and the rough set distribution characteristics of salt spray corrosion resistance evaluation of steel structure reinforced concrete in seaside construction are extracted. Taking the double steel plate-concrete composite shear wall as the research object, the stiffness stress distribution of steel structure reinforced concrete in seaside construction is obtained.

$$x_m(t) = \sum_{i=1}^{I} s_i(t) e^{j\varphi_{mi}} + n_m(t), -p+1 \le m \le p \tag{1}$$

According to the conversion section method and the analysis method of force balance, the analysis model of salt spray corrosion stress of reinforced concrete of steel structure is constructed. The rigidity of the composite section is $N = n-(m-1)\tau$. The distribution set of salt spray corrosion resistance of insulation foam material of the external wall of the building is calculated. The distribution densities of tensile concrete and steel beam elements are obtained as follows:

$$\gamma_i = \frac{\frac{1}{w}\sum_{l=0}^{w-1}\left[x_i(k-l)-\mu_i\right]^3}{\left(\frac{1}{w}\sum_{l=0}^{w-1}\left[x_i(k-l)-\mu_i\right]^2\right)^{3/2}} \tag{2}$$

$$\kappa_i = \frac{\frac{1}{w}\sum_{l=0}^{w-1}\left[x_i(k-l)-\mu_i\right]^4}{\left(\frac{1}{w}\sum_{l=0}^{w-1}\left[x_i(k-l)-\mu_i\right]^2\right)^{2}} - 3 \tag{3}$$

The damage characteristic distribution of bending capacity of members δ_k becomes $\delta_{ik}(t)$:

$$\delta_{ik}(t) = G\left(V = k \middle| U_i, \Theta(t)\right) \tag{4}$$

The corrosion solution is prepared by using a mixed solution of sulfuric acid and nitric acid to obtain the component of the salt-resistant and corrosion-resistant analysis of the steel structure in the coastal building construction, as shown in Fig. 1.

According to the component model of the salt-resistant and corrosion-resistant test of the steel structure in the coastal building construction shown in Fig. 1, the salt-resistant and corrosion-resistant performance observation of the concrete member is carried out. According to the analysis, the characteristics of salt-resistant and corrosion-resistant pre-stress of steel structures in the coastal construction are analyzed [13].

2.2. Characteristic analysis of salt-resistant and corrosion resistance of concrete

The method for evaluating the salt-fog corrosion performance of the steel-structure reinforced concrete in the

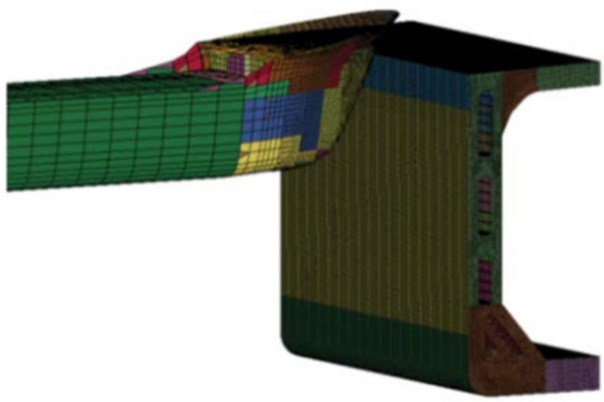

Fig. 1. Structure of salt-resistant and corrosion-resistant analysis of steel structure in the construction of the sea.

coastal building construction is M_i and M_j, the cluster distribution set is Clustdist(M_i, M_j), when ($i \neq j$, $1 \leq i \leq q$, $1 \leq j \leq q$), according to the material properties of the test pieces and the difference of the test device, The characteristics of negative bending moment can be evaluated by building the salt-fog corrosion resistance of steel-structure reinforced concrete in the construction of the sea:

$$\Psi(\omega) = \ln\left[\Psi(\omega)\right] = \sum_{k=1}^{n} \frac{c_k}{k!}(j\omega)^k + O(\omega^n) \tag{5}$$

The combined distribution characteristics of load-deflection of test plate are analyzed to realize the parameter collection and sample analysis to evaluate the salt spray corrosion resistance of reinforced concrete with steel structure in the construction of original seaside building [14], and the salt spray corrosion resistance is monitored according to the results of sample regression analysis. By analyzing the load-in-plane displacement distribution, the prediction function of salt spray corrosion resistance of reinforced concrete in bridge is obtained as follows:

$$Q = \frac{C_1 \sum_{i=1}^{k} \exp\left[-S_2\left(V_i - \mu\right)^2\right]}{1 + \exp\left[-S_1 \sum_{i=1}^{k} w_i\left(T_i - V_i\right)\right]} \tag{6}$$

According to the quantitative feature set of salt spray corrosion resistance evaluation of steel structure reinforced concrete in seaside construction, the later pressure data mining is carried out, and the salt spray corrosion resistance of concrete spalling layer is analyzed in the core area [15]. The ultimate load of thermal insulation foam material for building exterior wall is obtained:

$$\text{Sn} = \frac{\sum_{i}^{n} \max_{j=1}^{m} t_{ij}}{\sum_{i=1}^{n} n_i} \tag{7}$$

$$\text{PPV} = \frac{\sum_{j=1}^{m} \max_{i=1}^{n} t_{ij}}{\sum_{j=1}^{m} \sum_{i=1}^{n} t_{ij}} \tag{8}$$

In the process of salt fog corrosion resistance test, under the action of steel bar tensile failure, the corrosion characteristic points of steel structure reinforced concrete in the construction of seaside building are analyzed, and the corrosion prediction of steel structure reinforced concrete in seaside construction is carried out according to the distributed reconstruction of stress characteristics [16].

3. Valuation of salt spray corrosion resistance of steel structure reinforced concrete in seaside construction

3.1. Tensile test of reinforced concrete

On the basis of the analysis model of prestressed characteristics of reinforced concrete and the analysis of salt fog corrosion resistance of steel structure concrete in seaside construction by using the characteristic parameter estimation method of shear capacity, the salt fog corrosion resistance of steel structure reinforced concrete in seaside construction is evaluated. In this paper, a predictive control method of salt fog corrosion resistance of steel structure in seaside construction based on vertical load characteristic analysis is put forward by Khil et al. [17]. The characteristic parameter estimation method of shear capacity is used to analyze the salt fog corrosion resistance of steel structure concrete in seaside construction. The nearest adjacent point of pressure film is expressed as $X_{\eta(n)}$, increases gradually with the increase of load. Under the action of adjusting parameter a, b, the distribution state function of salt spray corrosion resistance of steel structure reinforced concrete in seaside construction is obtained.

$$\tilde{u}_{e|v,k} = \tilde{u}_{e,k} + \tilde{\Sigma}_{ve,k}^{T} \tilde{\Sigma}_{vv,k}^{-1} \left(v_k - \tilde{u}_{v,k}\right) \tag{9}$$

$D = \left(d_\gamma\right)_{\gamma \in \Gamma}$ is defined as the test set of salt spray corrosion resistance of steel structure reinforced concrete in seaside construction, and the statistical feature distribution is $\{x(t_0+i\Delta t)\}$, $i = 0, 1, \ldots, N-1$. By the method of steel bar strain measurement and plate angle binding measurement, the tensile resistance of reinforced concrete is tested, and the stress characteristic parameters are obtained as follows:

$$X = \left[s_1, s_2, \cdots s_K\right]_n = \left(x_n, x_{n-\tau}, \cdots, x_{n-(m-1)\tau}\right) \tag{10}$$

where the $K = N-(m-1)$, represents the load-deformation stress yield component, the vertical deflection load is:

$$x_n = a_0 + \sum_{i=1}^{M_{AR}} a_i x_{n-i} + \sum_{j=0}^{M_{MA}} b_j \eta_{n-j} \tag{11}$$

Where a_0 is the initial eigenvalue between the plate angular reaction beam and the test plate, and x_{n-i} is the statistical distribution sequence of tensile and yield stresses of the tensile thin film. Considering the effect of bond slip, the iterative formula of salt spray corrosion test is obtained as follows:

$$x\left(t_{n+1}\right)' = X_{m+1}(m) \tag{12}$$

The tensile test of reinforced concrete is carried out on the basis of the analysis.

3.2. Salt-resistant and corrosion-resistant optimization of steel structure in the construction of the sea

Considering the tensile film effect reasonably, analyzing the prestress characteristics of reinforced concrete, analyzing the corrosive failure form, analyzing the load-deformation curve of steel structure test plate in seaside construction [18], the fuzzy decision formula for evaluating the salt fog corrosion resistance of steel structure reinforced concrete in seaside construction is obtained as:

$$\text{DOI}_{a,b} = \frac{\left|I_{a,b}\right|}{\left|I_a\right| + \left|I_b\right| - \left|I_{a,b}\right|} \tag{13}$$

Combined with the finite element theory of the shell, under the constraint of the elastic proportional strain limit, the correlation function of the salt fog corrosion test of the steel structure steel bar concrete in the coastal building construction is as follows:

$$\mathrm{CPC}_{a,b}=\left(\sum_{i=1}^{|I_{a,b}|}\left(d_{a,i}-\bar{d}_a\right)\times\left(d_{b,i}-\bar{d}_b\right)\right)/\left(\sqrt{\sum_{i=1}^{|I_{a,b}|}\left(d_{a,i}-\bar{d}_a\right)^2}\times\sqrt{\sum_{i=1}^{I_{a,b}}\left(d_{b,i}-\bar{d}_b\right)^2}\right) \tag{14}$$

In the formula, $\mathrm{CPC}_{a,b}$ is the directional feature of salt fog corrosion resistance evaluation of steel structure reinforced concrete in seaside construction. $d_{a,i}$ and $d_{b,i} \in [1,5]$ represent the correlation constraint coefficient. The load bearing test of concrete simply supported slab is carried out by using commercial concrete pouring method. The conditional probability density function of salt fog corrosion resistance is obtained.

$$p\left(R\middle|U,V,\sigma_R^2\right)=\prod_{i=1}^{n}\prod_{j=1}^{m}\left[N\left(R_{ij}\middle|g\left(U_i^T V_j\right),\sigma_R^2\right)\right]^{I_{ij}^R} \tag{15}$$

wherein $N(x\,|\,\mu,\sigma^2)$ represents the confidence function of salt fog corrosion resistance of typical failure modes. According to the analysis, the failure form analysis of reinforced concrete is realized, and the calculation formula is as follows:

$$C_n^{''}=AC_{n-1}^{n-p}+e_n \tag{16}$$

$$C_n=MC_n^{n-p+1}+w_n \tag{17}$$

Under the condition that the number of cracks at the top of the plate is basically stable, the corrosion lag coefficients *A* and *M* are obtained as follows:

$$A=\left(2^{-1},2^{-2},\Lambda,2^{-p},2^{-p+1}\right) \tag{18}$$

$$M=\left(1,0,\Lambda,0\right)_p \tag{19}$$

The parameter distribution of salt spray corrosion resistance assessment is expressed as follows:

$$m_k=E\left[x^k\right]=\int_{-\infty}^{+\infty}x^k f\left(x\right)dx \tag{20}$$

$$\mu_k=E\left[\left(x-\eta\right)^k\right]=\int_{-\infty}^{+\infty}\left(x-\eta\right)^k f\left(x\right)dx \tag{21}$$

According to the analysis, the vertical deflection characteristic of the steel structure in the coastal building construction is extracted, and the tensile test of the reinforced concrete is carried out by the method of the reinforcement strain measurement and the plate angle binding measurement [19–21].

3.3. Experimental test analysis

In order to test the application performance of this method in the evaluation and optimization of salt spray corrosion resistance of steel structures in seaside building construction, the corrosion test of concrete was carried out by using the seawater corrosion system shown in Fig. 2.

The material mechanics performance parameter of the steel structure in the given coastal construction is Es = 200 GPa, the water inlet pipe of the sea water is a PVC pipe with a diameter of 30 mm, the Poisson's ratio of the salt-resistant and corrosion-resistant test is μ = 0.26, the compressive strength is 40 MPa, and the formula distribution of the steel structure material in the coastal building construction is shown in Table 1.

According to the parameter setting, the salt-resistant and salt-resistant corrosion of the steel structure in the coastal building construction under different failure modes is analyzed, and the corrosion result is shown in Fig. 3.

The analysis shows that the method can effectively realize the salt-resistant fog corrosion prediction control of the steel structure in the coastal building construction, and test the corrosion degree prediction value and the test field of the steel structure in the coastal building construction, and the result is shown in Fig. 4. The analysis and simulation results show that the method is adopted to carry out the design of the steel structure in the coastal construction, the salt resistance is good, the yield of the reinforced concrete is enhanced, and the resistance rigidity of the steel structure in the construction of the sea is improved. Test steel structure salt spray corrosion failure mode, as shown in Fig. 4.

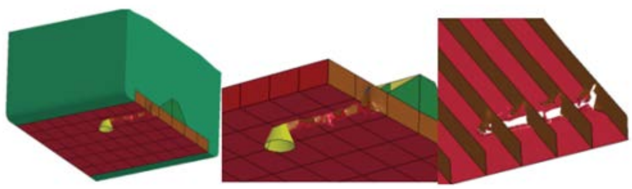

Fig. 2. Seawater corrosion system.

Table 1
Basic formula of building exterior wall thermal insulation foam sample

Sample	Hydrate (%)	Base material (%)	Alkaline coating (%)	Latex matrix (%)	Concrete iron (%)
1	45	32	42	3	32
2	33	15	37	5	36
3	56	17	21	6	43
4	32	145	64	5	43

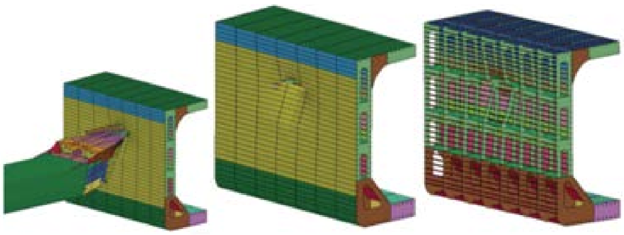

Fig. 3. Corrosion results of steel structures in seaside construction.

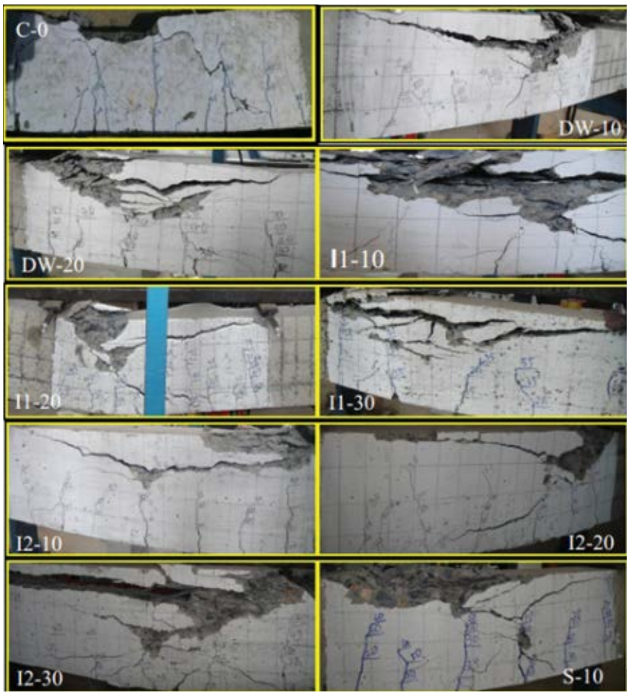

Fig. 4. Salt spray corrosion failure mode of steel structure.

The analysis of Fig. 4 shows that the method can effectively monitor the salt fog corrosion of steel structure in the construction of the sea, and the results of the numerical analysis are shown in Fig. 5.

Fig. 5 shows that the method is high in the output accuracy of the salt-resistant and salt-resistant corrosion monitoring of the steel structure in the coastal building construction.

4. Conclusion

The salt fog corrosion resistance of steel structure in seaside construction is analyzed. Combined with the prediction and optimization control method of salt spray corrosion resistance of steel structure in seaside construction, the optimal design of seaside building concrete is carried out. The characteristic parameter estimation method of shear capacity is used to analyze the salt fog corrosion resistance characteristics of steel structure concrete in seaside construction, and the combined load-deflection distribution characteristic quantity of test slab is analyzed. According to the results of sample regression analysis, the corrosion resistance of steel structure is monitored, and the strain difference of steel structure in seaside construction is analyzed quantitatively. It is found that this method can improve the corrosion resistance of steel structure in seaside construction, enhance the yield strain ability of reinforced concrete and predict the corrosion resistance of salt fog.

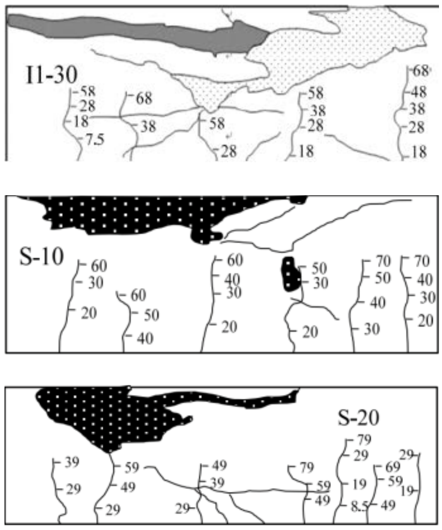

Fig. 5. Description of corrosion crack expansion diagram of steel structure in seaside construction.

References

[1] W. Gao, W. Wang, A tight neighborhood union condition on fractional (g,f,n′,m)-critical deleted graphs, Colloq. Math., 149 (2017a) 291–298.

[2] R. Ahmadi, O. Rashidian, R. Abbasnia, F.M. Nav, N. Usefi, Experimental and numerical evaluation of progressive collapse behavior in scaled RC beam-column subassemblage, Shock Vib., 2016 (2016) 3748435, doi: 10.1155/2016/3748435.

[3] L. Wang, T. Yang, B. Wang, Q. Lin, S. Zhu, C. Li, Y. Ma, J. Tang, J. Xing, X. Li, H. Liao, D. Staiger, Z. Hu, F. Yu, RALF1-FERONIA complex affects splicing dynamics to modulate stress responses and growth in plants, Sci. Adv., 6 (2020) eaaz1622, doi: 10.1126/sciadv.aaz1622.

[4] F. Dinu, I. Marginean, D. Dubina, I. Petran, Experimental testing and numerical analysis of 3D steel frame system under column loss, Eng. Struct., 113 (2016) 59–70.

[5] A.G. Vlassis, B.A. Izzuddin, A.Y. Elghazouli, D.A. Nethercot, Progressive collapse of multi-storey buildings due to sudden column loss—Part II: application, Eng. Struct., 30 (2008) 1424–1438.

[6] X.-h. Yu, D.-g. Lv, Probabilistic seismic demand analysis and seismic fragility analysis based on a cloud-stripe method, Eng. Mech., 3 (2016) 68–76.

[7] L. Lin, X.Z. Lu, P.F. Han, Analysis of impact force of large commercial aircraft to a rigid wall, J. Vib. Shock, 34 (2015) 158–163.

[8] B. Xu, X. Zeng, Experimental study on the behaviour of reinforced concrete beams under impact loadings, China Civ. Eng. J., 47 (2014) 41–51.

[9] P. Yang, Z. Wu, Y. Chen, Y. Guo, H. Song, Spectral irradiance distribution in underwater light field generated by an LED light source, J. Coastal Res., 103 (2020) 453–457.

[10] W. Gao, W. Wang, New isolated toughness condition for fractional (g,f,n)-critical graph, Colloq. Math., 147 (2017b) 55–65.

[11] J. Mao, D. Hong, R. Ren, X. Li, The effect of marine power generation technology on the evolution of energy demand for new energy vehicles, J. Coastal Res., 103 (2020) 1006–1009.
[12] D.G. Lü, X.H. Yu, Z.H. Chen, Lateral seismic collapse fragility analysis of RC frame structures, J. Harbin Inst. Technol., 43 (2011) 1–5.
[13] D.G. Lü, X.H. Yu, Theoretical study of probabilistic seismic risk assessment based on analytical functions of seismic fragility, J. Build. Struct., 34 (2013) 41–48.
[14] X.H. Yu, D.G. Lü, H.Q. Zheng, Seismic sideway collapse fragility analysis based on typical failure modes, J. Build. Struct., 35 (2014a) 8–15.
[15] Y. Yu, Z.Y. Wang, D.G. Xu, Speed and current sensors fault detection and isolation based on adaptive observers for induction motor drivers, J. Power Elect., 5 (2014b) 967–979.
[16] H. Berriri, W. Naouar, I. Bahri, Field programmable gate array-based fault-tolerant hysteresis current control for AC machine drives, IET Electr. Power Appl., 6 (2012) 181–189.
[17] S.K.E. Khil, I. Jlassi, J.O. Estima, N. Mrabet-Bellaaj, Current sensor fault detection and isolation method for PMSM drives, using average normalised currents, Electron. Lett., 52 (2016) 1434–1436.
[18] Y. Hao, H. Hao, Z.X. Li, Influence of end friction confinement on impact tests of concrete material at high strain rate, Int. J. Impact Eng., 60 (2013) 82–106.
[19] V. Bindiganavile, N. Banthia, Size effects and the dynamic response of plain concrete, ASCE J. Mater. Civ. Eng., 18 (2006) 485–491.
[20] T. Krauthammer, M.M. Elfahal, J. Lim, T. Ohno, M. Beppu, G. Markeset, Size effect for high strength concrete cylinders subjected to axial impact, Int. J. Impact Eng., 28 (2003) 1001–1016.
[21] Y.Q. Wang, X.L. Liu, M. Liu, Experimental study on deformation performance of I-section beam with longitudinally variable thickness flanges, J. Harbin Inst. Technol., 49 (2017) 24–31.