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ГАШЕННЯ КОЛИВАНЬ КОНСТРУКЦІЙ БАЛКОВОГО ТИПУ ГРОМАДСЬКОЇ БУДІВЛІ ДП КСКЦ ПАТ «КОНЦЕРН СТИРОЛ»

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Анотація. У статті розглянуті динамічні випробування елементів балкового типу, встановлених на фасаді ДП КСКЦ «Концерн Стірол» при реконструкції, для гашення коливань яких запропоновано динамічний гаситель. Згідно з архітектурною ідеєю фасаду дані елементи представляють не зв'язані між собою консолі вильотом 6–7 м, що схильні до ефекту вихрового збудження коливань у вітровому потоці, за яких можуть виникати стійкі вібрації підвищеного рівня поперек вітрового потоку. У процесі реалізації проекту виникла необхідність натурного визначення динамічних параметрів даних конструкцій та застосування спеціальних динамічних гасителів. Для зниження амплітуд коливань у резонансному режимі розроблені, виготовлені та змонтовані динамічні гасителі коливань для даних конструкцій. Виконані натурні динамічні випробування роботи конструкції з гасителями коливань та без них з метою отримання інформації про ефективність їх застосування.

Ключові слова: динамічні випробування, гаситель коливань, вихрове збудження коливань.

ГАШЕНИЕ КОЛЕБАНИЙ КОНСТРУКЦИЙ БАЛОЧНОГО ТИПА ОБЩЕСТВЕННОГО ЗДАНИЯ ДП КСКЦ «КОНЦЕРН СТИРОЛ»

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Аннотация. В статье рассмотрены динамические испытания элементов балочного типа, установленных на фасаде ДП КСКЦ «Концерн Стирол» при реконструкции, для гашения колебаний которых предложен динамический гаситель. Согласно архитектурной идеи фасада данные элементы представляют не связанные между собой консоли вылетом 6–7 м, что подвержены эффектам вихревого возбуждения колебаний в ветровом потоке, при которых могут возникать устойчивые вибрации повышенного уровня поперек ветрового потока. В процессе реализации проекта возникла необходимость натурного определения динамических параметров данных конструкций и применения специальных динамических гасителей. Для снижения амплитуд колебаний в резонансном режиме разработаны, изготовлены и смонтированы динамические гасители колебаний для данных конструкций. Произведены натурные динамические испытания работы конструкций с гасителями колебаний и без них с целью получения информации об эффективности их применения.

Ключевые слова: динамические испытания, гаситель колебаний, вихревое возбуждение колебаний.

VIBRATION SUPPRESSION OF GIRDER STRUCTURES OF PUBLIC BUILDING OF GOVERNMENT-OWNED ESTABLISHMENT OF CONCERT AND SPORTING COMPLEX CENTRE OF PUBLIC JOINT STOCK COMPANY OF «STIROL CONCERN»

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Abstract. The paper deals with the dynamic tests of beam type elements installed on the facade of the Government-Owned Establishment Of Concert and Sporting Complex Centre of Public Joint Stock Company of «Stirol Concern» (later on, «Concert Hall») at the refurbishment, where to suppress of vibrations, the dynamic suppressor has been offered. In accordance to the architectural concept of the facade, the above-mentioned elements represent the cantilever disconnected between each other with the cantilever element overhang of 6–7 m and are subjected to the effects of eddy excitation of vibrations in the wind flow where the stable vibrations of increased level can appear across the wind flow. During the realization process of the design, the necessity of full-scale determination of the dynamic parameters of the above-mentioned constructions and application of special dynamic suppressors has been sprung up. To decrease the vibration amplitude at the resonant mode, the dynamic suppressors for above-mentioned constructions have been worked out, made and erected. The full-scale dynamic tests of constructional operation with vibration suppressors and without in order to obtain a piece of information of their application efficacy have been carried out.

Keywords: dynamic tests, vibration suppressors, eddy excitation of vibrations.

Introduction

In practice of the building enterprise there was appeared the problem of refurbishment of building of former Palace of Culture of Horlovka built by the standard design No. 2C-06-6/69 «Palace of Culture with a spectator' hall to 1200 seats» in 1981. In constructional plan, the building was represented by the reinforced frame with bearing brick walls.

The refurbishment of design of the Concert Hall was developed and realized in 2013; the problems of functioning of rooms and design of the contemporary architectural image of a building were solved. According to the architects' design, decorative pylons of the main entrance are broken off on the parabolic curve forming the taking off wing structure (Fig. 1). Accordingly to the design, the mounting of steel long-sized truss structures of cantilever type which subsequently were subject to facing and tiling with composite materials and were decorative elements of the central facades.

Decorative elements of the central being the separate disconnected cantilever elements between each other with the cantilever element overhang of 6–7 m accomplish complex vibrations in wind flow. Because of the central facade shape non-ordinariness, the flow model can be obtained by blowing of a building model in a wind tunnel. How such kind of wind pressure to the given elements at the strength and stiffness analyses are not intense and at design the problem of bearing capacity was solved by application of a framework of a steel truss with a chord from rolled double Ts (Fig. 2).

The most complicated problem is resonance phenomena when the displacement amplitudes are of great importance and meaning. In this case, the effects of beats can arise due to the density of the lower frequencies spectrum. One of the most dangerous types of resonant disturbances for the given facade decorative elements is the eddy excitation effect of vibrations in the wind flow [2, 3, 5–7, 8, 12], at which the stable vibrations of

Figure 1. General view of the building after refurbishment (facades 1–19).

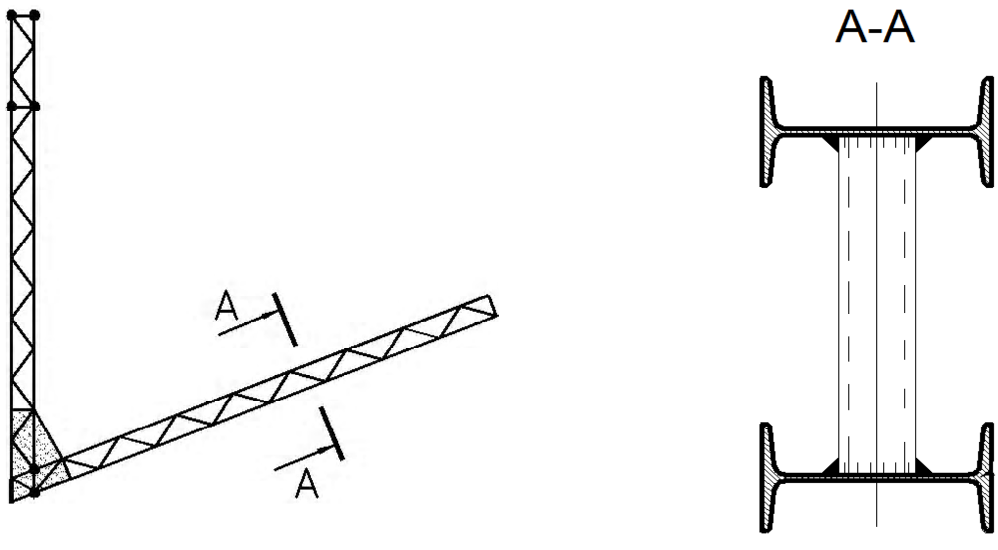


Figure 2. Diagram of Г– shaped truss of facade decorative elements.

increased level across the wind flow at periodic vortex separation (Karman vortices) can arise. The amplitudes of the vibrations depend on a cross-section of elements, stiffness and dissipative characteristics of elements in the vibrations plane [8–10].

During construction at brick pylons stripping for execution of reinforcement there was appearance of necessity of amendments introduction into design conceptions which have changed the diagram of trusses fixing of facade decorative elements. In this connection, the problem of experimental check stipulated in design diagrams of the dynamic characteristics of facade decorative elements has been appeared, the more so, as some parameters of vibratory systems, e.g., dissipative characteristics can be obtained just only at carrying out of full-scale tests [10, 11, 13].

Full-scale tests

The purpose of carrying out of the full-scale tests was determination of factual dynamic characteristics and determination of the necessity of special vibration damper application for steel truss.

The construction of the steel trusses decorative elements situated above the main entrance of the building are Γ – shaped elements (Fig. 2), the vertical part of which is fastened to the strengthening elements on the building facade. The vertical part is the truss, the chord of which is made of double T No. 18 and bent and welded pipe with the dimensions of 180×100×5, the grid is made of the bent and welded pipe with the dimensions of 60×3 mm. The horizontal part has been made in the form of a truss with a chord made of a double T No. 18, the grid of the truss has been made of a bent and welded pipe with the dimensions of 60×3mm. The given structures are sheeted with composite material from the outside.

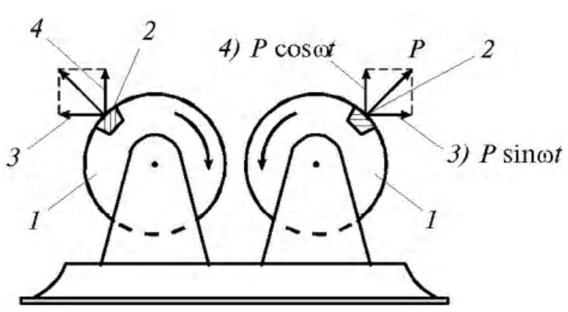
Natural and stimulated vibrations of the structure were originated with application of a vibration machine of electromechanical and eccentric type (Fig. 3) made at the Donbas National Academy of Civil Engineering and Architecture. It has two rotatable in step opposing directions eccentrics motion-controlled by an electric motor. The machine is attached to the construction and smooth change of angular velocity of the vibration machine shafts makes it possible to study the constructional behaviour at various forcing frequencies.

To determine the dynamic parameters of trusses construction, the vibration machine was attached on the separate standard elements (Fig. 4. a, b), the vibrations were induced in plane of the trusses and stimulated vibrations at machine operation and natural vibrations at «running-out» (Fig. 4. c, d) were registered [1, 4].

Registered vibrational records of the natural vibrations were undergone to the chamber treatment and frequencies and logarithmic decrements of the vibrations compared with values accepted at design were determined (Table 1).

The analysis of the dynamic parameters of the trusses shows, that change of the structural schematic drawing has led to the stiffness increase of the supportive fixing and three-dimensional space structure on the whole and the increased values of natural vibrations of fundamental tone measured experimentally demonstrate about it. But the values of logarithmic decrements of the vibrations, the magnitude of which is determined only by experiments, has been turned out to be to 2.5–3 times less than assumed at execution designs. On the basis of recomputation of constructions with application of obtained experimental data on condition of appearance of stable resonance vibrations in terms of their eddy excitation by the wind flow, the decision about application of

a)



b)

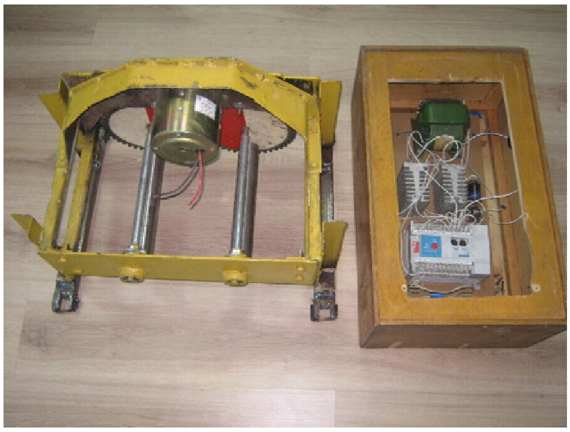


Figure 3. Vibration machine with a control block: a) basic diagram of activity; b) general outlook.

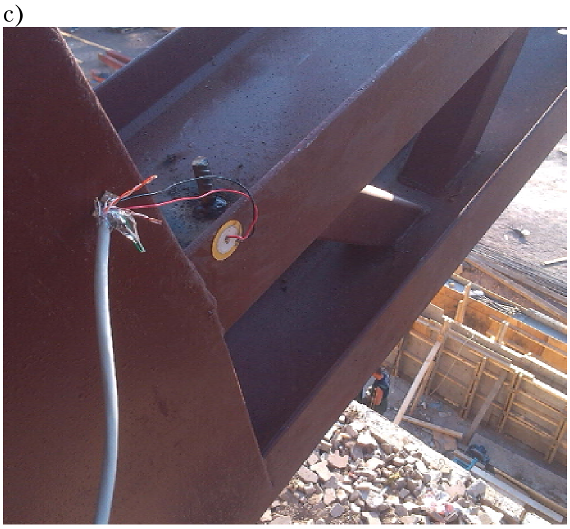
vibration suppressors to absorb the vibrational energy of the trusses structures has been accepted.

To decrease the vibrational amplitudes at the resonant mode of the trusses structures of decorative elements of the entrance group, special plate suppressors being vibrational in opposite phase to the truss were used (Fig. 5). The suppressor consists of a plate fixed on the trusses

a)

b)

c)



d)

Figure 4. Registration of trusses vibration: a, b) placement of vibration machine on the trusses; c) installation of piezoelectric transducers; d) registration of vibrations.

Table 1. The results of dynamic parameters comparison

Place of tests conducting	Frequencies of natural vibrations of of fundamental tone, Hz			Logarithmic decrements of the vibrations		
	Actual	Of designed model	Difference	Actual	Of designed model	Difference
Truss No.1	8.288±0.004	7.095	16.8 %	0.007± 0.0014	0.03	328 %
Truss No.2	7.190±0.003	6.378	12.7 %	0.0088± 0.0029	0.03	241 %
Truss No.3	6.713±0.024	6.147	9.2 %	0.0077± 0.002	0.03	290 %
Truss No.4	6.591±0.002	6.012	9.6 %	0.0081± 0.0022	0.03	270 %
Truss No.5	6.905±0.057	6.802	1.5 %	0.0265± 0.0062	0.03	13 %

a)

b)

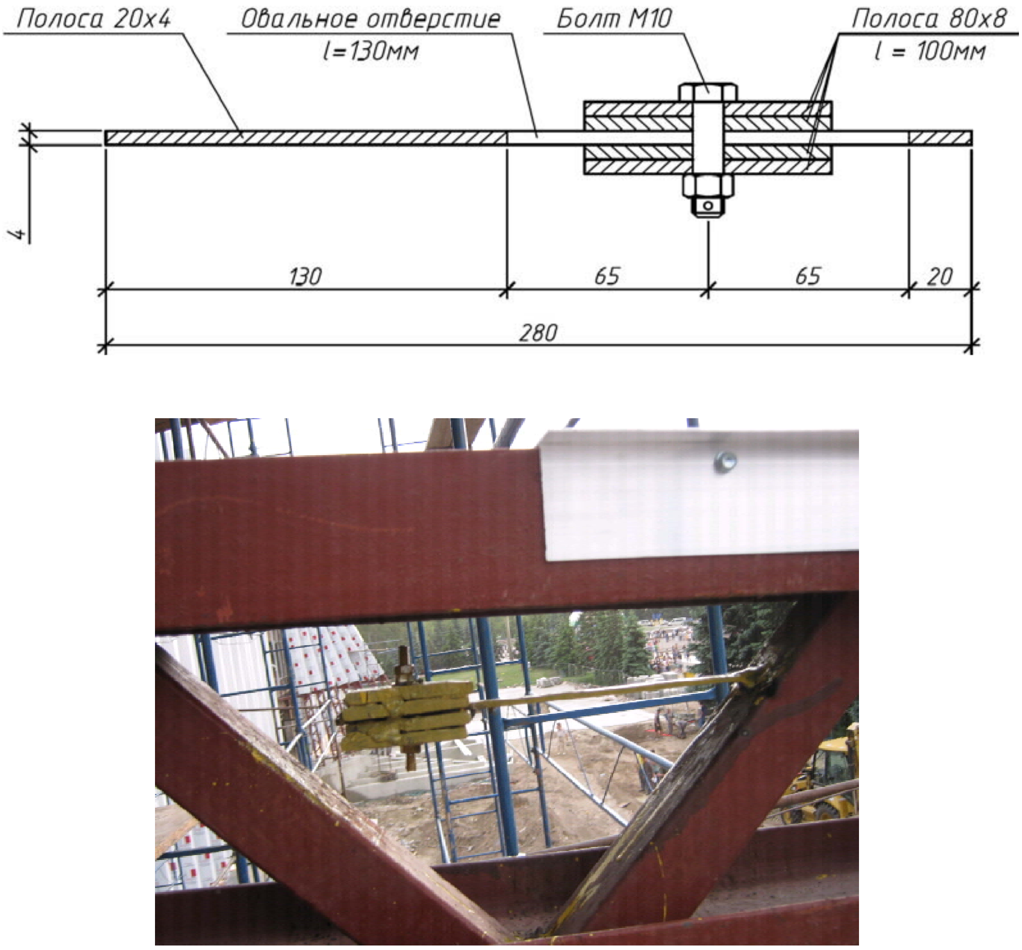


Figure 5. Diagram of the plate vibrational suppressor: a) principal diagram; b) the suppressor installed on the truss structure.

by a cantilever with the concentrated mass on the edge of the plate, which can be moved along the plate for fine adjustment. The adjustment of the suppressor is made by the mass movement so that in the resonant mode of the truss vibration, the damper vibrates in the opposite phase to the principal structure, that leads to decrease of the vibrational amplitude of the principal structure and dissipation of vibrational energy. To increase dissipative forces ar trusses vibrators, there were special spacers made of fluoroplastic are used in spots of abutment to steel trusses of composite facing.

The suppressor installed on the truss was subjected to the fine adjustment process by the way of localized mass transfer along the plate and vibrational amplitudes were fixed in the resonant mode for the structure both with the suppressor and without it. In this connection, the absent mass of outside sheeting distributed along the truss length at the moment of damper adjustment from composite materials was added as equivalent mass localized at the edge of cantilever partially at the expanse of vibration machine mass, partially at the expanse of additionally fastened load.

The process procedure of adjustment and operation analysis of the suppressor is the following:

1. The suppressor vibrations are excluded from the system by its fixation to the truss with the wire. In this case, just only the truss performs the vibrations (Fig. 6, a).
2. The resonant mode was sorted out by the frequency control of driving force. As the mode with maximum movement amplitude. The movements were fixed as by a vibrational record in the mode of real time on the monitor screen and additionally on the rod installed nearby with the tested truss (Fig. 6, b).
3. The suppressor fixation was taken off and the mode with the least movement amplitude was

selected by the movement of the localized mass. In this position, the mass was fixed, fastened with welding and amplitude indices were kept for subsequent analysis.

The analysis results of modification of the truss vibrational amplitude at plate suppressor installation for 4 main types of the trusses are given in Table 2.

Logarithmic decrements of structural vibrations at rest without a suppressor or with it were determined by the obtained vibrational records. The data have been given in Table 3.

On the basis of the analysis results, the conclusions were made that application of offered plate suppressors permits to decrease the vibrational amplitude in the resonant mode in 1.5–2 times and increase logarithmic decrement of vibrations in 3–3.5 times. Using experimentally confirmed results on amplitude reduction and logarithmic decrement increase, the absence of manifestation of stable resonant vibrations at eddy excitations for the structures with installed suppressors. In the result, it was decision making about realization of plate suppressors on the trusses

a)

b)

Figure 6. Adjustment of the plate vibrational suppressor: a) suppressor fixation for elimination of its vibrations; b) movement amplitude determination by the rod.

Table 2. Vibrational amplitude of the cantilever edge of the steel trusses

Place of tests conducting	Vibrational amplitude of the truss without suppressor, cm	Vibrational amplitude of the structure with suppressor, cm	Relation of vibrational amplitude
Truss No.1	3.5	2.4	1.45
Truss No.2	3.0	2.0	1.50
Truss No.3	2.8	1.6	1.75
Truss No.4	2.7	1.6	1.68

Note: The vibrations were caused by vibrational machine with capped eccentrics with mass of 1.387 kg each, situated on the distance of 0.06 m from an axis of rotation of a gear.

Table 3. Logarithmic decrements of trusses vibrations

Place of tests conducting	Logarithmic decrement of structural vibrations without suppressor	Logarithmic decrement of structural vibrations with suppressor	Relation of vibrational decrements
Truss No.1	0.007	0.0273	3.90
Truss No.2	0.0088	0.0277	3.15
Truss No.3	0.0077	0.0278	3.61
Truss No.4	0.0081	0.0285	3.52

of the decorative elements of the central entrance into the building (Fig. 7).

Conclusions

1. For the steel trusses of the decorative elements of the central entrance there have been tests during which the actual dynamic characteristics of structural vibrations have been determined and they have been compared with values stipulated at design. The application of special vibrational suppressors has been proved.
2. The version of the special plate vibrational suppressor has been offered. The realization and adjustment of a suppressor for the number of trusses have been made. In the result, it has been increased in 3–3.5 times and decreased vibrational amplitude of the trusses in 1.5–2 times. It has been obtained that application of plate suppressors permits to increase logarithmic vibrational decrement.
3. The application of plate suppressors for all the trusses of the decorative elements of the central entrance has been proved.

Figure 7. Realization of plate suppressors on the steel trusses of the central entrance.

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