POSTER

Dissipative Braced Frames with Steel and Concrete Active Links

Portiques entretoisés dissipatifs avec poutres en acier et béton

Dissipative Rahmen mit aktiven Aussteifungen aus Stahl und Beton

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1. INTRODUCTION

The structural system of eccentrically braced frames with steel and steel-concrete dissipative links is an alternative to the two traditional structural system adopted in steel structure multi-storey buildings to withstand seismic actions, i.e. rigid joint frames and bracing trusses. The adoption of this structural typology for multi-storey residential buildings has shown the following advantages: (a) possibility of free spaces for openings and passages especially helpful in the aseismic adaptation of existing buildings; (b) characteristics of strength and stiffness in elastic field typical of bracing trusses with moderate P-Δ effects also for multi-storey tall structures; (c) capability of wasting energy dissipation under a seismic event of high intensity thanks to the remarkable ductility of the link. This ductility is due to the presence of large shear and moment plastic deformations and to the possibility of a stable cyclic behaviour in elastoplastic range. The structural system can be so designed as to let the columns and diagonal remain in elastic range up to the full link collapse. Therefore the link becomes the controlling element of the structure behaviour during the seismic event.

2. RESEARCH PROGRAM

Eccentricity, i.e. the link length, is a basic factor in the elastoplastic response of the structural system. The use of greater eccentricities allows the reduction of the plastic deformations required from the link, while for small eccentricities the system gets more rigid in the elastic phase but the demand for shear and moment plastic deformation is also greater. The deformation depends on the type of mechanism and therefore corresponds either to an angular deformation in the case of "shear link" or to a plastic hinges rotation in case of "moment link". The dimensioning and checking of multi-storey frames through a dynamic analysis in elastoplastic range [1] have shown that very good results are possible in relation to strength, stiffness and ductility characteristics, if the mechanical characteristics of the link are continuously varied by using welded plated girders instead of rolled beams and if great eccentricities are adopted.

Experimental investigation on the links [2] carried out by means of welded plate girders and concrete flanges allowed to determine:

- the choice criteria of geometrical and mechanical parameters of the link;
- the collapse mechanisms of the links and the respective "structural factors" in conformity with Eurocode EC8;
- constructive solutions to optimize the dissipating capability of the cyclic loads structural system when large plastic deformations are present.

The collapse behaviour of the links essentially depends on a correct design of the web stiffening and of the link-column connection.

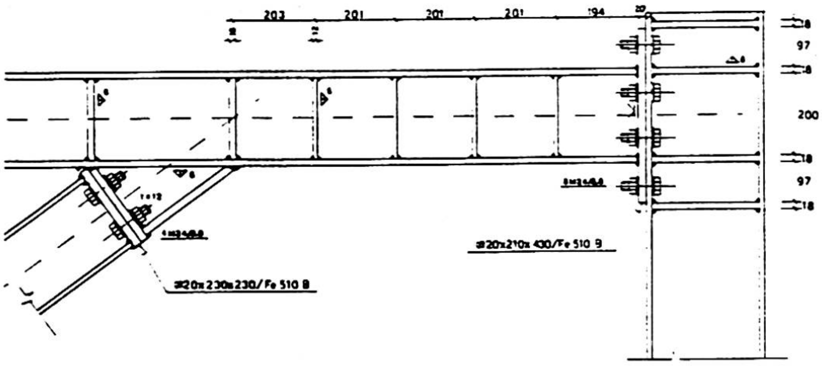

Fig. 1 Details of the active links

A range between two ribs equal to the web height, for $a/t_w = 40$, and a bolted flange connection have been adopted for the experimental research, Fig.1.
The tests have been carried out on five welded girders with flanges of two different dimensions and with a concrete slab in order to investigate about the collapse mechanism and the characteristic parameters of ductility, stiffness reduction and absorbed energy in compliance with ECCS indications for cyclic test. The experimental tests have proved that a stable cyclic behaviour is obtained whenever the web shear yielding precedes the flange yielding and the link ductility increases when the bending plastic hinges are contemporarily present at the link ends. These objects are attained either by increasing the flange thickness or by setting a concrete slab; both solutions reduce the web local instability phenomena. The results of experimental tests have helped to find the link F.E. in DRAIN-2D program modelled as a sandwich beam and also to set up the cyclic load code when the link hardens with web shear yielding.

3. COMMENTS OF RESULTS

The force-displacement hysteretic loops obtained by a test beam with displacement imposed in elastic and elastoplastic range are sketched in Fig.2 as well as loops obtained by sandwich-modelling the link.
The ratio between the slope of Young's coefficient in plastic and elastic range (hardening ratio ρ) has given values included between 0.038 and 0.041. The shear collapse has proved 1.4÷1.6 times greater than the value corresponding to the web primary yielding, when the imposed displacements were 9÷10 times greater than at elastic limit. On applying the experimental and numerical results to the design of industrial and residential buildings, the structural system proved excellent under acceleration histories of simulated or recorded earthquakes. As a matter of fact the links built with welded or composite beams allow to set "dissipative valves" which lower down to 6 or 7 times the seismic inertial forces in the structural steel.

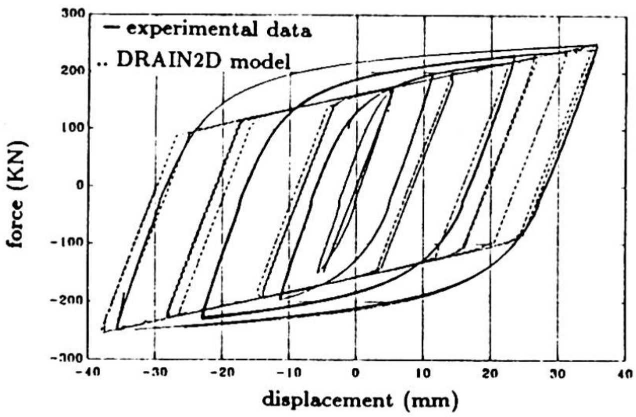

Fig.2 Hysteretic loops of a test beam

REFERENCES

1. GUSELLA V., SELLERI F., SPADACCINI O., Seismic behaviour of eccentrically braced multy-storey frames, Costruzioni Metalliche, n.2-3, 1988.
2. GUSELLA V., SELLERI F., SPADACCINI O., Indagine sperimentale su elementi corti di trave in telai irrigiditi da diagonali eccentriche, Acciaio, n.12,1990 (in italian).

Hybrid Isolation System Using Friction-Controllable Sliding Bearings

Système hybride d'isolation basé sur des appuis glissants à friction

Hybride Isolation mit Gleitlagern beeinflussbarer Reibung

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1. INTRODUCTION

The sliding isolation system represents a reliable vibration suppression technology. Such a sliding isolation system, however, has some limitation in its capability; it is not efficient for small to medium earthquakes, and it tends to suffer a large sliding displacement during large earthquakes. The objective of this research then is to develop a hybrid isolation system using friction-controllable sliding bearing, where by controlling the friction force, the sliding displacement will be confined within an acceptable range, while keeping the overall isolation performance optimal under the circumstances.

2. HYBRID ISOLATION SYSTEM

In the hybrid isolation system, a friction controllable sliding bearing or variable friction bearing (VFB) is used instead of an ordinary sliding bearing. The VFB is a carved out steel disk with a sliding material placed around its perimeter and a fluid chamber inside. The fluid pressure and the corresponding up-lifting force created by the fluid pressure can be controlled, resulting in a controllable friction force. Pressure control hardware system including computers connected to the VFB's controls the pressure according to a control algorithm so as to achieve an optimal isolation performance .

A simple one-degree of freedom model composed of a mass supported by VFB's is considered. A control algorithm based on the instantaneous optimal control theory[1], has been developed.

3. SHAKING TABLE TEST [2]

3.1 Description of Test

A pilot isolation system, including the VFB's and a pressure control system, has been constructed and tested on a shaking table. The model structure was a rigid body with the total mass of 12 tons supported by four VFB's The sliding surface of the VFB consists of 1 mm thick brass plate while a stainless steel sheet is placed on the shaking table to provide a sliding surface over which the VFB's can slide.

The control system consists of a 16 bit microcomputer with a numerical co-processor , and 12 bit A/D and D/A converters. Based on the response signals measured by sensors, the computer calculates the pressure control signal according to the control algorithm, and the signal was sent to the servo amplifier.

The shaking table test was conducted under unidirectional (horizontal) earthquake as well as sinusoidal excitations.

3.2 Test Result

A test performed off-line indicated that the friction force decreases linearly as the pressure increases within the interface. Also in another test, the relation between the pressure and the friction force under control signals was established. The results of these tests are modeled and used in the simulation. Performance of the hybrid control system is compared with that of the passive isolation system under different intensities of input seismic motion. As shown in Figure 1, the hybrid control system performs better than the passive system in the sense that the reduction of response acceleration has been achieved for small to medium seismic inputs, and at the same time, the maximum displacement has also been reduced. The residual displacement has been found to be nearly zero under hybrid control, which appears to be another advantage of this hybrid system.

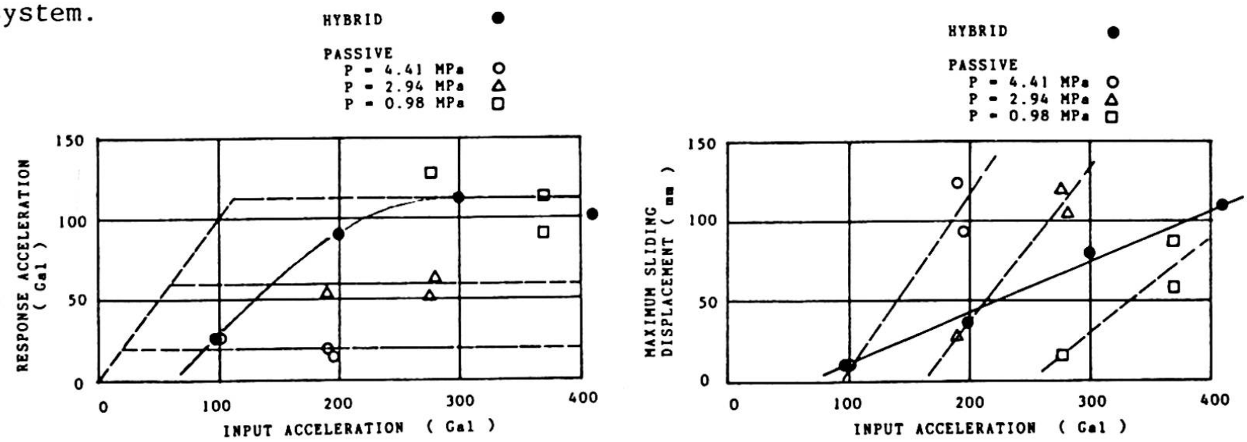

Fig. 1 Hybrid and Passive Cases

4. SIMULATION

The test results were simulated numerically exhibiting reasonably good agreement. Since some of the parameters and mathematical models involved some degrees of uncertainty, the good agreement observed is an indication of robustness of the hybrid system. The parametric study performed, also by means of simulation, identified most appropriate control parameters.

5. CONCLUSIONS

(1) Significantly beneficial effect of the hybrid control on the reduction of the sliding displacement as well as the reduction of the input force, has been verified through shaking table test.

(2) The pilot hybrid isolation system using the VFB's appears to be quite robust in the fact of uncertainty involved in various aspects of the control model.

(3) Structural response simulated by the numerical analysis showed good agreement with the observation in the shaking table test, implying that the numerical model identified in the present study represents the reality reasonably well.

REFERENCES

[1] YANG,J.N.,et al., " Optimal Control of Nonlinear Flexible Structures", Technical Report of NCEER-88-0002. (1988)

[2] FENG,Q.,et al.," Hybrid Isolation System Using Friction Controllable Sliding Bearings", 8 th VPI and SU Symposium on Dynamic and Large Structures, May 1991.

235 MWe Containments in India

Enceinte de réacteur nucléaire de 235 MW, Inde

Das Containement für einen 235 MW Kernreaktor

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Two units each of 235 MWe reactors are under construction at two sites at Kaiga (Kaiga 1 & 2) and Ravatbhata (RAPP 3 & 4) using standardised designs. The civil designs for containment structures are based on identical design philosophy but making suitable site dependent modifications. The containment has to remain integral and effective in the most unlikely combination of the postulated events wherein the extreme natural disasters can combine with the internal accidental release of steam/air mixture creating high pressure and temperature loading. To decide upon the magnitudes of design basis events arising out of natural disasters, detailed studies of specific sites were made. After establishing the design parameters, most appropriate containments capable of protecting the reactors from the environment and the environment from the internal accidents were designed.

1. THE NATURAL DISASTERS AND DESIGN BASIS

1.1 Earthquake Parameters:

The IAEA guidelines were used to determine the S1(OBE) and S2(SSE) level earthquakes. In determining the SSE, studies of regional geology alongwith RIS potential were used with a seismotechtonic approach to establish the maximum potential magnitudes of earthquakes on various causative faults. The maximum ground motion at the site is then calculated using appropriate attenuation laws.

1.2 Wind Effects:

RAPP has a meteriological station from which data is available. The statistical analysis of the same was carried out to establish the extreme design wind velocities. For Kaiga site - in absence of meteriological station at site - codal recommendations are adopted with suitable modification to return period for special structures. Kaiga site has a special feature of forming atmospheric inverted bowl effect due to existence of high hills all around covering a large percentage of periphery around the site.

1.3 Flood Effects:

Both of the project sites are located on the foreshore banks of the reservoirs formed by constructing dams across major rivers. On these rivers, more dams have been built upstream of the sites. The safety of these dams has been studied for extreme events. In addition, flood routing studies have been made to establish the maximum water level at site due to postulated dam break of the upstream dams.

1.4 Geological studies:

Geotechnical parameters were established including the rock levels and foundations conditions. A detailed study of aggregate sources was made since a portion of Kaiga region has a small percentage of strained quartz.

2. SOLUTIONS EVOLVED

2.1 Reference is made to Fig. 1 showing the section through the containment. Double containment philosophy has been used wherein any leakage from the inner containment is entrapped in the annular space and is not allowed to mix with the environment before scrubbing and filtering.

The inner containment in prestressed concrete is designed to remain leaktight and its structural response fully within elastic ranage for all the combinations of loading. In addition, ultimate safety factors are checked by limit state approach to assess the strength aspects. Outer containment in RCC is designed for extreme wind and the earthquake effects. The common base raft is designed as water retaining RCC structure giving due consideration to the shrinkage and heat of hydredation effects.

2.2 At Kaiga site, due to earthquake effect there is a case of lift off of the raft, loosing contact of over 60% of area. Also the embedment effect in rock is not available due to highly joined nature of the rock mass with thin lenses of chovrite and mica schists and small cover of rock over the founding level. A ring of prestressed flexible rockanchors was provided in annular space. The rock mass was treated carrying out the consolidation grouting. At RAPP site rock anchors were not necessary due to low seismocity and also good massive intact rock, giving embedment effect, was available.

2.3 The plant is located at elevations above computed flood water levels postulating upstream dam break and further flood routing.

2.4 Petrographic studies were carried out on the stone samples from source quarries to assess the presence of strained quartz in the rock. Experiments were carried out, using the mortar bar expansion method, using varying contents of total alkali in the cement samples. Based on these studies cement of low alkali was specified and specially manufactured for use.

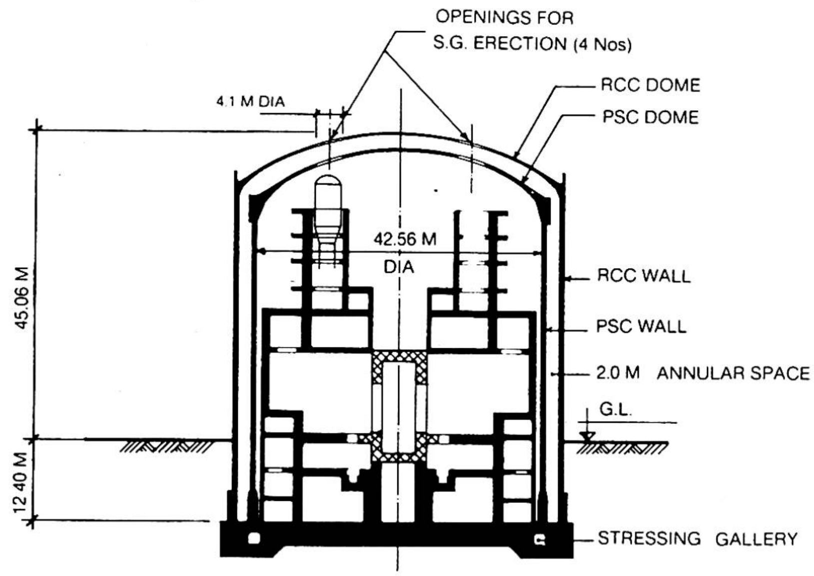

Fig. 1 Cross Section - Kaiga Atomic Power Project

Seismic Analysis for Achieving Economy and Safety in Bridge Structures

Etudes sismiques en vue de réaliser l'économie et la sécurité dans les structures de ponts

Erdbebenberechnungen für sichere und ökonomische Brücken

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1. INTRODUCTION

Static seismic coefficient method is generally used to carry out seismic analysis of bridge structures in India. Here seismic forces are evaluated from a coefficient specified by the code depending on the zone in which the bridge is located. Dynamic characteristics of the structure ignored resulting in very large forces and uneconomical design for bridges with tall piers. A case in point is the prestressed concrete railway bridge over River Sardan on Jammu Udhampur Rail Link, in India. General elevation and cross sectional details of the bridge are shown in the sketch below. A detailed dynamic analysis is required to be done for such structures to achieve economy in design and resultant saving in cost, without compromising on the safety of the structure.

2. DYNAMIC ANALYSIS

Dynamic analysis for this bridge involves determination of period and mode of oscillation for first five modes for the pier with superstructure mass lumped at the top and computation of horizontal shears and moments at various levels by mode participation method. Since the pier rests on bed rock, it is idealised as a cantilever fixed at base and divided into number of nodes along the height. The pier is described along Y-axis in the X-Y plane with oscillations being studied in X-direction. At the lowest node, all degrees of freedom are restricted. Other nodes are free to translate in X-direction and rotate about Z-axis, other degrees of freedom being restricted.

Mode shapes for first five modes of vibration with corresponding period of vibration are evaluated by using SAP 80 PROGRAM. Thereafter, mode participation factors are calculated for different modes. Average acceleration coefficient for each mode is calculated corresponding to appropriate period and damping (5% in this case) from Fig.2 of IS:1893 and also horizontal seismic coefficient is computed for each mode as under:

(As per Notations in IS: 1893) $\alpha h(r) = \frac{Sa}{g} (r)\ F\ I \beta$

Lateral load Q i (r) acting at any level i due to rth mode of vibration is given by the following equation:

$Q\ i\ (r) = Wi\ \phi\ i(r)\ Cr \alpha\ h\ (r)$

$Vi\ (r)$ Resultant shear at i level $= \sum_{\lambda=1}^{\lambda} Qi\ (r)$

3. RESULTS AND COMPARISON OF SEISMIC FORCES

Results of dynamic analysis for a typical pier of height 35.0 m are presented below in table 1 :

Table - 1

Mode No.	Period	$\frac{Sa}{g}$	$h = \frac{Sa}{g}$	Fp 1.P
1.	1.435	0.08	0.030	
2.	0.117	0.20	0.075	
3.	0.039	0.16	0.060	
4.	0.02	0.14	0.0525	
5.	0.012	0.13	0.049	

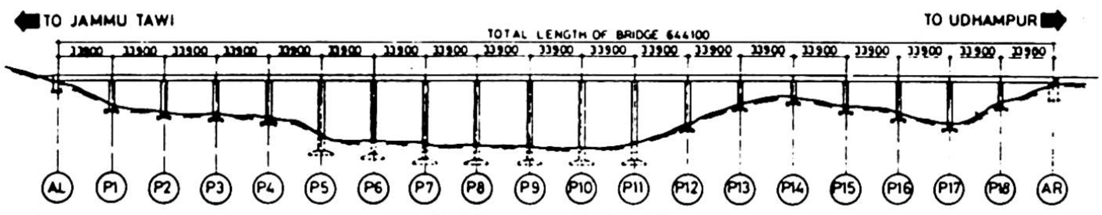
Resultant base moment by dynamic analysis = 10230 KN-M.
Resultant base moment by static coefficient (0.075g) = 25000 KN-M.

A comparison of seismic forces shows that the base moment obtained from dynamic analysis can be as low as 40% of the value computed by static seismic coefficient method. This results in economy in size of footing and a low reinforcement in the pier. Thus, a more realistic value of seismic analysis is obtained by dynamic analysis, especially for bridges with tall piers, resulting in reduction in cot of substructure.

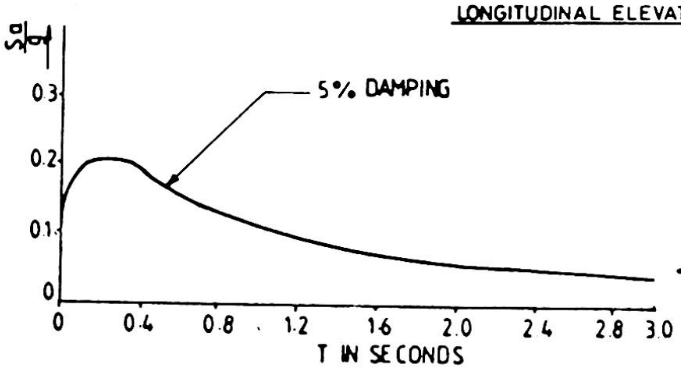
References:

1. IS: 1893 - Indian Standards Code of Practice for Earthquake Resistant Design of Structures.

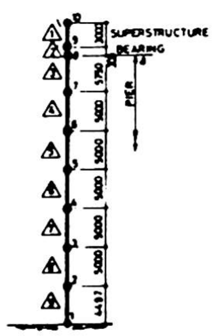
2. Earthquake Resistant Design of Bridges, University of Roorkee, India 425 - Refresher Course, 1984.



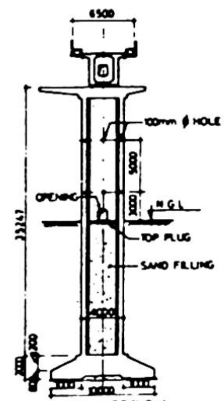
LONGITUDINAL ELEVATION



AVERAGE ACCELERATION SPECTRA



IDEALIZATION OF PIER



CROSS SECTION OF PIER

Anti-Seismic Protection of Monumental Buildings

Protection contre les séismes des bâtiments et monuments

Erdbebensicherung von Monumentalbauten

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The poster-contribution refers to monumental buildings and particularly to churches of three-cusped plane wide-spread in the Carpatho-Danubian-Pontic area, where tectonic earthquakes frequently occur. The seismic response of these buildings mainly depends on their shapes. For the new buildings the anti-seismic protection consists in approaching the centers of mass and twist by using certain models of analysis. The decision of anti-seismic strengthening of the existing buildings is based on the map of damages, well drew up and correctly interpreted. The validity of the adopted solution is checked up by comparing the dynamic characteristics of monumental building, electronically measured, before and after strengthening.

La contribution-poster concerne surtout les bâtiments monumentaux et, en particulier, les églises à plan trilobé largement répandues dans la zone Carpato-Danubienne-Pontique, où les tremblements tectoniques surviennent fréquemment. La réponse sismique de ces bâtiments dépend principalement de leur configurations. Pour les nouveaux bâtiments la protection contre les séismes consiste dans le rapprochement des centres de masse et de torsion par l'utilisation certain modèles de calcul. Pour les bâtiments existents la décision de consolidation contre les séisme a pour base la carte des avaries, bien tracée et correctement interprétée. La validité de la solution adoptée est vérifiée par la comparaison des caractéristiques dynamiques du bâtiment, mesurées électroniquement, avant et après la consolidation.

Der Posterbeitrag bezieht sich im allgemeinen auf die Monumentalbauten und besonders auf die kleeblattformigen gebauten Kirchen, die in den pontischen, Donau- und Karpatengebieten sehr verbreitet sind und wo sehr häufig tektonische Erdbeben eintreten. Die seismische Antwort dieser Gebäude hängt grundsätzlich von ihrer Gestalt ab. Für die neuen Gebäude besteht der antiseismische Schutz aus dem Aneinanderrücken der Massen- und Drillungsmittelpunkte durch die Anwendung einiger einfachen Rechnungsmodelle. Bei den vorhandenen Gebäuden gründet sich die antiseismische Konsolidierungentscheidung auf die gut aufgezeichnete und genau interpretierte Beschädigungskarte. Die Gültigkeit der angenommenen Lösung wurde durch die Vergleichung der dynamischen Merkmale des Gebäudes untersucht, die sowohl vor als auch nach der Konsolidierung gemessen werden.

The oldest monumental buildings preserved in the Carpatho-Danubian-Pontic area are churches. For centuries they were the most representative creations of eccleastic and monumental architecture. Erected with stone or brick masonry these Eastern Churches of Balkan-Byzantine style were always an evidence of the level of technical knowledge and artistic refinement reached during their epoch. They also reflect the foreign influence on the autochthonous art of building.

Unfortunately, strong tectonic earthquakes frequently occur in this area.The main focus being located in the Carpathian curvature and at a depth of 150 km, it influences the whole area. The Eastern churches of three-cusped plane seeming to show an intrinsic sensitivity to earthquake actions. In the course of time some of them were completely destroyed. Others survived being, however, more or less, damaged. Often by strengthening parts of the original works were altered or even definitely sacrificed.

As concern the damages caused by earthquakes, first there should be mentioned the steeples. As a rule the masonry columns of the steeples are horizontally sheared at their bottoms and tops. The steeples of Wallachian churches yielded easier to shearing forces than those of Moldavian churches. Consequently, now in Bucharest, one churche out of three has false, wooden steeples.

Apse walls of the nave and altar are also severely damaged. The typical damages consist in vertical cracks when these curved or polygonal walls are completely closed, and in 45^{o} inclined cracks when there are e.g. openings for windows. The same two types of cracks have been developed in the straight walls of the ante-naves, especially when they were not braced at their tops.

The semi-circular arches as integral parts of the surrounding walls, designed to narrow the vaulted space and to support the cupola or steeple are also severely damaged by earthquakes. Generally, the cracks appear at the arch crown as well as at the quarter of the free spans. Such damages are often caused by ties mounted too eccentrically. A faulty foundation also allow damages to the apse walls and transverse arches. This is the case of churches rebuilt in a new masonry style over ancient foundations of wooden churches burnt or stone churches destroyed by seisms.

There are, however, churches of three-cusped plane which lasted for centuries without being damaged at all. It has been observed that in certain rather restricted areas churches of about the same size, being erected in the same period and with a comparable kind of foundations and brick-work behaved quite differently.The explanation seems to be in the variety of the adopted shapes.Therefore, it could be assumed that since long ago certain anti-seismic shapes were more or less conciously searched for. But no written rules or documents were preserved so far. Only the old Master`s Manole legend is going on as an ancient technical code.

The monumental buildings and particularly the churches have at least one axis of symmetry, and their seismic response depends mostly on their shapes. In the stage of design the anti-seismic shaping consists in balancing the buildings by approaching the centers of mass and twist. The structural solutions of anti-seismic strengthening consist in coating the walls, framing the openings and bracing the building body, but only after checking up, and if necessary improving, the foundations.

Effective Protection against Natural Disasters

Protection efficace contre les catastrophes naturelles

Systeme zum effektiven Schutz gegen Naturkatastrophen

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At interactions between concrete structures and dynamic loads during earthquakes,high temperatures,fire,agressive surroundings,oil products,often reduces their load-carrying capasity : for further usage of such structures, they either have to be strengthered or change out-rigth.

At Novopolotsk polytechnic institute in Bielorussia was innovated new methods of reconstructions and reinforcing concrete construction LAM with in essence is a fast and effective solution to sush reconstruction problems.

Reconstruction methods LAM conditionally could be divided into four groups :

- devices for strengtherning concrete beams which have lost anchorage with private steel reinforcement;
- devices for strengtherning concrete coloumns;
- methods for reinforcing concrete slabs with multiple hollows;
- local changes of prefabricated concrete slabs.

Principal schemes of some of the methods are shown on figures 1;2;3.

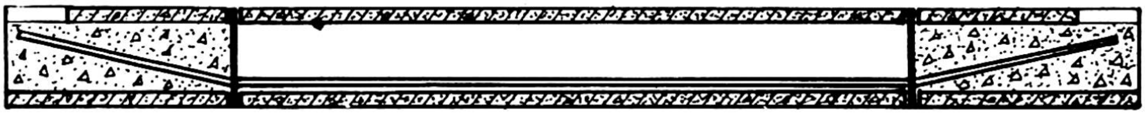

Fig. 1

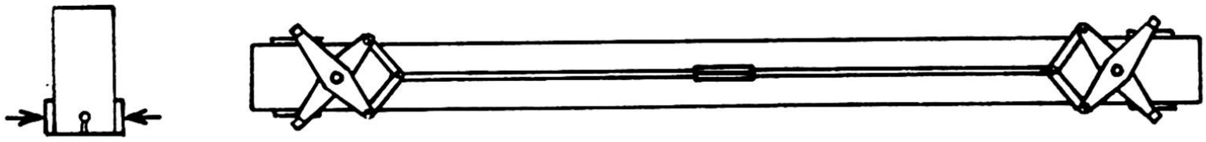

Fig.2

Beneficial to already deformed constructions as a result of accidents,natural disasters or agressive environments,witnesses the following quality indicators for any of these devices :

- 15-30 minutes for mounting;
- labour input 0,6-0,75 Man/hour for mounting;
- increase in load-bearing capasity 2 3 times.

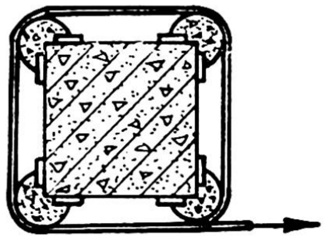

Fig.3

Experimental and theoretical researches have been fully carried out with reinforced constructions.A set of project documentations and working quidelines with engineering drawings have been worked out.

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