

CARLO BLASI - MARTA PECCHIOLI

PHOTOELASTIC STRESS ANALYSIS IN MASONRY STRUCTURES

Photoelasticity has not been used for a detailed analysis of the static behaviour of masonry structures.

Among few interesting exceptions we must notice the paper by R. March and R. Jonash (1), where horizontal load effects are studied, in section models of famous gothic cathedrals. Such models, however, had been obtained by cutting a whole plate of photoelastic material, by reproduction only of the section profile of those buildings; so the particular static characteristics of the framework to be investigated. The leaking of tensile strength, first of all, had not been taken into account.

Within the studies which are in progress at the Istituto di Costruzioni di Firenze, Facoltà di Architettura, whose object in the structural analysis of masonry, we try to apply the photoelastic methods, assuming particular models, able to simulate the static behaviour of the masonry structural elements.

As a first approach, dry jointed plane elements have been investigated, so to simulate a structural scheme similar to a masonry framework loaded in its plane (2).

Such models have been made by traditional materials used in photoelasticity (perspex and araldit B 12), but much care was needed in the assembly of such elements, in order to avoid distress phenomena in the contact surfaces. Furthermore, these models have been fitted between two glass plates, with the aim to warrant, during the tests, the stability of such frames.

Some examples of the tests, which have been carried out, are discussed in what follows.

Fig. 1 shows the model of the behaviour of a wall continuous, subjected to a concentrated load, supported by elastic base: a) isoclinics 15°; b) isostatics lines c) isochromatics.

Fig. 2 shows a rectangular opening in a wall, with upper girder, subjected to a concentrated load and on rigid supported. a) isoclinics 15°; b) isostatics line; c) isochromatics.

Fig. 3 shows a bracket with concentrated load. a) isoclinics 15°; b) isostatics line; c) isochromatics.

It is easy to note the region of stress concentrations, and while some elements show a clear bending loading, with remarkable increasing of stresses.

More recent studies have been carried out about particular structural elements, aiming to evaluation of the stress state.

Three of the examples are presented: a pier, an arch, a flat ceiling; the arch and the ceiling have been deduced from plates n° XXIX and XXXIII of the Rondelet treatise.

Pier

The pier object of the test described in that memory is the structural behaviour of a pier, made by eight hewnstones, with no tensile strength, subjected to eccentric load.

The obtained results show general agreement, except for a few significant differences, with the theory of eccentrically loaded beams.

In fig. 4 the following data are collected: isostatics lines, isochromatics and the bending diagrams of stress, with reference to the middle point and the contact boundaries of the single stones.

Such values are obtained as mean value of the 4 intermediate elements.

Test data:

dimensions of hewn stones	cm 5 × 2,5 × 1
fringe value	kg/cm.n = 15
external load	kg = 130
eccentricity	cm = 1
resultant force sez. A	Ra = kg 126,8 (error 2,5%)
resultant force sez. B	Rb = kg 133,9 (error 3%)

Arch

The structure behaviour of an arch, made by 11 stones, has been studied, taking a vertical distributed load into account.

Fig. 5 shows isostatics lines, isochromatics and the stress diagrams in some section.

Test data:

dimensions of arch	cm 24 × 12 × 1
fringe value	kg/cm.n = 24
external load	kg = 6 × 32,5

Flat ceiling

A vertical load acting on a flat ceiling, made by 5 stones, has been investigated. Fig. 6 shows the isostatics lines, the isochromatics and the stress diagrams, in some section.

Test data:

dimensions of flat ceiling	cm 17 × 3 × 1
fringe value	kg/cm.n = 15
external load	kg = 64

Conclusions

Meaningful comparisons with the actual behaviour of masonry frameworks require the solution of several problems, just as the role of mortar layers and the brick cracks due to internal tensile stress. However, the results obtained by the afore described tests seem to encourage to further develop these searches.

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THEME:

STRUCTURES

TITRE:

ANALYSE DES CONTRAINTES DANS LES STRUCTURES EN MAÇONNERIE, A L'AIDE DES METHODES PHOTO-ELASTIQUES

RESUME:

Le présent travail, effectué dans le cadre des recherches sur les constructions en maçonnerie poursuivies actuellement à l'Institut de la Construction de la Faculté d'Architecture de Florence, représente la première tentative d'une recherche systématique sur le comportement des structures en maçonnerie par le moyen des techniques photo-élastiques.

Ce mémoire présente les résultats, obtenus par observation photo-élastique, d'essais effectués sur des éléments structurels: cloisons, corbeaux, pilastres, arcs et plates-bandes. Les expériences tentées ont permis de déterminer l'état des contraintes existant dans les structures examinées.

Les résultats démontrent les possibilités considérables qu'offre la photo-élasticimétrie dans le domaine de l'analyse statique des constructions en maçonnerie, domaine où, à de rares exceptions près, elle n'avait jamais été utilisée.

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SUBJECT: STRUCTURES

TITLE: PHOTOELASTIC STRESS ANALYSIS IN MASONRY STRUCTURES.

SUMMARY:

The operations described are a part of the research now being done at the Building Institute of the Florence Architecture Faculty and represent the first approach to systematic research on the behaviour of coursed masonry or brick structures with the aid of photo-elastic techniques.

The paper gives the results obtained by photo-elastic observation following tests on architectural members: inside walls, corbels, pilasters, arches and lintel courses. It was possible by this method to determine the degree of stress existing in the structures examined.

The findings demonstrate the remarkable potentialities of photo-elastic methods for the static testing of coursed masonry and brick buildings — a field in which, with rare exceptions, they had never been previously used.

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TEMA: ESTRUCTURAS

TITULO: ANALISIS DE CARGAS EN ESTRUCTURAS A BASE DE MUROS POR METODOS FOTOELASTICOS

SUMARIO:

El presente trabajo, realizado en el programa de investigación que se viene desarrollando actualmente dentro del Instituto de la Construcción en la Facultad de Arquitectura de Florencia, sobre construcciones a base de muros, es el primer intento para establecer una investigación sistemática del comportamiento de estructuras murales, mediante el empleo de técnicas fotoelásticas.

En este reporte se presentan los resultados obtenidos de la observación fotoelástica de pruebas sobre elementos estructurales: muros divisorios, ménsulas, pilastras, arcos y platabandas. Los experimentos realizados, permitieron aislar el estado de tensión existente en las estructuras estudiadas.

Los resultados muestran notables posibilidades ofrecidas por la fotoelasticidad en el campo del análisis estático de construcciones a base de muros, donde, salvo raras excepciones, no se había aplicado antes.

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Предмет : СТРУКТУРА

Название : ИЗУЧЕНИЕ ОБЯЗАТЕЛЬНЫХ ПРЕДПИСАНИЙ для КАМЕННЫХ и
КИРПИЧНЫХ СТРОЕНИЙ с ПРИМЕНЕНИЕМ ФОТО-ЭЛАСТИЧНЫХ
МЕТОДОВ

Краткое Описание :

Настоящая работа, совершенная в рамках изучения о каменных и кирпичных постройках, производимых в настоящее время в Институте для Строительства Архитектурного Факультета города Флоренции, представляет из себя первую попытку систематического изыскания и прочности каменных построек, при помощи фото-эластичных методов.

Эти записи описывают результаты полученные при фото-эластичных наблюдениях к которым подвергают различные составные части строения : перегородки, подпорки, пиластры, закругленные двери или арки и перемычки. Произведенные опыты позволили установить ряд обязательных предписаний, которым должны подчиняться изучаемая постройка.

Полученные результаты наглядно показывают большие возможности существующие при употреблении способов фото-эластометрии в области статического анализа предлагаемого к кирпичным и каменным постройкам, где они, с редкими исключениями, еще почти что никогда не были употреблены.

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TEMA : STRUTTURE

TITOLO : ANALISI DELLE SOLLECITAZIONI IN STRUTTURE MURARIE CON METODI FOTOELASTICI.

SOMMARIO :

Il presente lavoro, effettuato nell'ambito delle ricerche che vengono attualmente svolte presso l'Istituto di Costruzioni della facoltà di Architettura di Firenze sulle costruzioni in muratura, è il primo approccio per una ricerca sistematica sul comportamento delle strutture murarie, mediante l'impiego di tecniche fotoelastiche.

In questa memoria vengono presentati i risultati, ottenuti dall'osservazione fotoelastica, di prove su elementi strutturali: setti murari, mensole, pilastri, archi e piattabande. Le esperienze fatte hanno permesso di individuare lo stato di tensione esistente nelle strutture studiate.

I risultati mostrano le notevoli possibilità che la fotoelasticità offre nel campo dell'analisi statica di costruzioni in muratura, ove, salvo rare eccezioni, non era mai stata applicata.