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Izlaganje sa znanstvenog skupa

BEHAVIOUR OF STONE FACADES IN URBAN CENTERS INNOVATIVE BUILDING TECHNOLOGIES

Antonio MONACO

Istituto di Architettura e Urbanistica, Facoltà di Ingegneria, Università di Padova, 35131 – Padova, Italia

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An innovative technology using stone and granite as exterior sheeting of modern steel and concrete tall buildings is presented.

Granites are chosen for the indubitable superior durability in any wheather and polluted atmosfere condition. But to guarantee durability stone sheets have to be mounted in such a way as to avoid any inner irregular stress. In particular stresses from deformation of the main structure must not be trasmitted to the exterior sheeting.

Moreover an all–proof wheather barrier has to be incorporated in the factory builded sheeting panel.

The innovative technology allowing use of granite and stone in facing of tall buildings is here presented along with two very important realisations: The North Tower in Genoa and the Canary Wharf in London.

Ključne riječi: Kamena pročelja, Ugrađivanje, Paneli, Trošenje

Prezentirana je inovirana tehnologija korištenja kamena za oblaganje pločama pročelja modernih željeznih i betonskih građevina.

Graniti su odabrani zbog nesumnjivo superiorne otpornosti prema troženju i utjecaju onečišćene atmosfere. Ali, otpornost kamenih ploča zagarantirana je ugrađivanjem na takav način da se izbjegnu bilo kakva unutrašnja naprezanja. Naprezanja zbog deformacije strukture objekta ne smiju se prenositi na vanjsku oblogu.

Osim toga, otpornost na vremenske promjene treba da je ispitana u tvornici u kojoj se prave paneli od ploča.

Inovirana tehnologija uz korištenje granita za oblaganje visokih građevina prezentirana je s dvije značajne realizacije: Sjeverni toranj u Genovi i Kanarsko pristanište u Londonu.

Introduction

Among the many applications of stone for the construction of facades of buildings, we connected with the use of these materials can be summed up as follows:

a) the conditions of the working environment of the stone in terms of rapid changes of temperature, air pressure and humidity or even water;

b)the conditions related to the building to which the facade is applied: deformations of its structure and settling of its foundation;

c) the internal tensions present in the stone as a result of its manufacture (quarrying and cutting) and installation;

d) the particular attention required to avoid the possibile accumulation of condensation, the freezing of which would crack the stone slabs.

Methods, techniques and materials

In the past time the most widely used cladding materials in tall buildings have been alluminum, for the framing structure, and glass for the surface panels, both of which resist the aggressive and corrosive attack of urban and industrial environments. At present other, more classical matherials, as stone, marble and granite, reveal its superbe weathering behaviour, provided that suitable building techniques are employed.

In general, granite is preferred for tall buildings since its more homogeneous composition allows it to be more securely anchored to the underlying structure. Moreover the low thermal dilatation coefficient reduces straining ot the sheets.

While marble is indubitably more appealing esthetically, one sometimes encounters problems of surface deterioration due to dust and smoke. An improper drainage of water behind the slabs, moreover, can result in the deformation of the facade caused by absorption.

The problems faced in mounting a stone facade depend essentially on whether the slabs are directly affixed in loco or whether prefabricated panels of stone and support are use. In the first case the technical problems consist primarily in aligning the slabs and keeping them flush with the planes determined by the underlying surfaces.

The use of prefabricated panels eliminates these problems, but requires greater consideration as regards the impact of the facade on the supporting building and also as regards the effect of wind on the panels.

For larger buildings, these added consideration are more than compensated for by the great reductions in both cost of materials and required execution time.

The San Benigno North Tower

Two examples of the use of these prefabricated panels are presented:
the North Tower San Benigno of Genoa, Italy and the basement Canary Wharf FC5 in London.

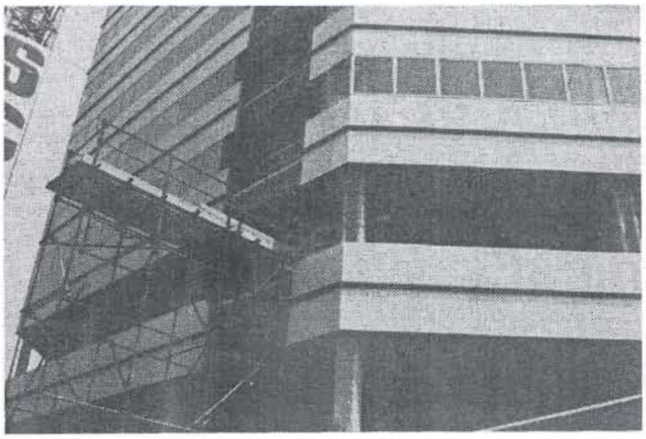

Fig. 1: San Benigno North Tower. Detail of cladding mounting.

The innovative technical solutions adopted in the composite glass–granite facade of the North Tower of Genoa (Italy) are developed by a group of industries:

The North Tower of Genoa (see Fig. 1), has been designed by Seicom (Genova, arch. Messina and arch. Lanata) with the architectural consulting of Skidmore, Owings & Merril of New York; General Contractor: S. C. I. SpA of Genoa; Permasteelisa (Treviso) is the general contractor for facing elements, Margraf (Vicenza) provided granites, Alpha (Massa) assembled and prebuilded granite sheeted panels and Bit (Treviso) builded steel frames.

The North Tower is the second, after the tower WTC, of a series of new »intelligent« office buildings in Genoa, each conceived, constructed and operated according to innovative architectural and bulding criteria, above all as regards the advanced technology incorporated in the construction.

The physical characteristics of the tower which most affected the planning and design of the facade were its overall heighs (127 m), the relatively tall storeys (3,55 m) and the floorplan, unusual for a building of these dimensions, which was a regular octagon with sides measuring 21 metres.

The position of the site, the Port of Genoa, presented severe atmospheric conditions of heavy rains with strong winds requiring the use of very sophisticated techniques for the anchoring of the facade.

The building consists in a central nucleus made of concrete (stairs, elevator passage, electric and technological plants) while the remaining parts, the major portion of the building, are composed of steel structures hinged to the concrete core.

The rigidity and stability provided by this type of construction facilitated, to some degree, the design of the facade in that the effects of the relative movements of the nucleus and external parts of the tower were reduced.

The facade was anchored to the main building structure along the storey slabs (140 mm thick) and on the steel perimetral beams using special crossbars.

In the absence of external scaffolding of the tower, all the major mounting of the facade had to be accomplished from within, with only minor finishing operations performed externally (such as joint sealing and controls).

The work on the continuous facade began when just 12 of the total 21 storeys to be covered by the facade were constructed. Completed, the building reached 24 storeys.

Given the impossibility of working outside the main building structure to mount the facade, finished prefabricated panels requiring only a minimum of external sealing were chosen.

The resulting facade is composed of alternating panels of granite–covered steel for support (see Fig. 1) all completely factory constructed off–site.

The exceptional water–resistence required by contract was obtained through a system of three pressurized barriers discussed elsewhere.

The detailed analysis carried out before beginning production and the high degree of industrialization and quality control permitted by the in factory construction of prefabricated panels resulted in considerable overall savings of both money and time with respect to a more traditional on–site approach.

The prefabricated panels of granite–covered steel (see Fig. 2) were composed fundamentally of a steel supporting frame with anchoring crossbars, external covering of granite slabs, toroidal granite border, upper support in alluminium for the window fixtures, prepainted, zinc–plated steel sheet as a barrier against air and water, glass wool thermal insulating panels and a layer of fire–proof plasterboard.

The steel frames are manifactured from welded rectangular hollow section profiles. Frames are corrosion protected by heat zinc electroploting (75 microns). Welding is accomplished with particular expedients in order to avoid straining produced by inner stresses, left behind in the zincage process. Frames are intended to bear loading from exterior facing stone sheet, from windows and from the wind design load.

Building allowance adjustements is foreseen and the joint reglage designed is 4 cm. Each panel covering is made of 6 sheets of grey »luna–perla« Sardinian granite, 1 m high and wide 1/18 of the whole side length, i.e. 1156 mm.

The toroidal horizontal border is made by »black Indian granite«. Clamping of horizontal border is obtained by two inox steel pins, entering obliquous into holes in the granite and fastened by epoxy resin.

Between the granite and the steel frame nylon or poliuretonic washers are employed.

Problems in manifacturing of granite

Manifacturing of toroidal granite elements has required a particular study in order to avoid micro crakings, which are possible when using traditional rotating saw.

A new drilling device (see Fig. 3) has been designed allowing to produce four colomns once, by means of four hollow cilinders, diamond teeth headed. This device reduces the waste of material and optimizes the number of pieces obtained from each stone block (see Fig. 4).

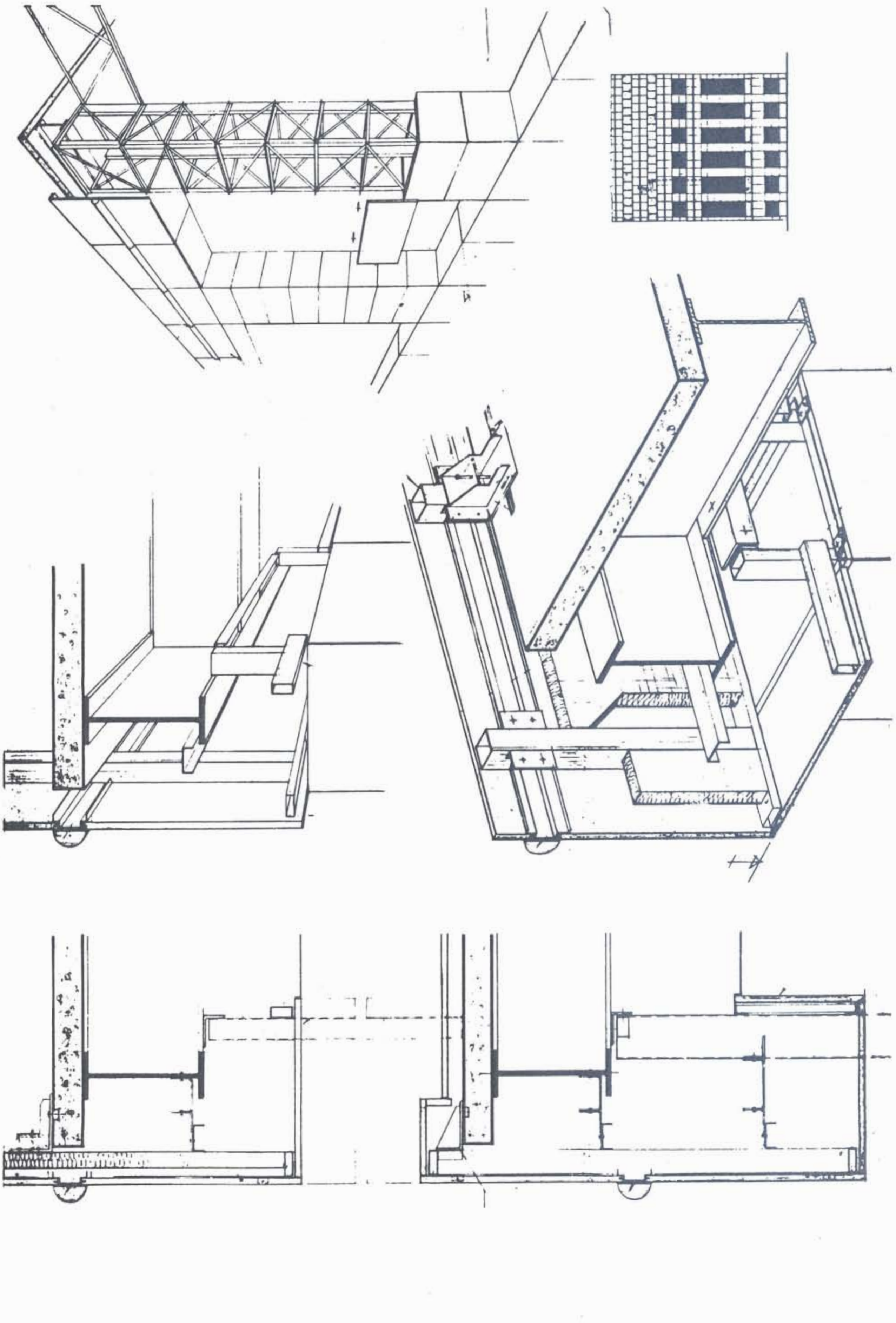

Fig. 2: San Benigno North Tower. Detail of the fixing devices and of the steel frames.

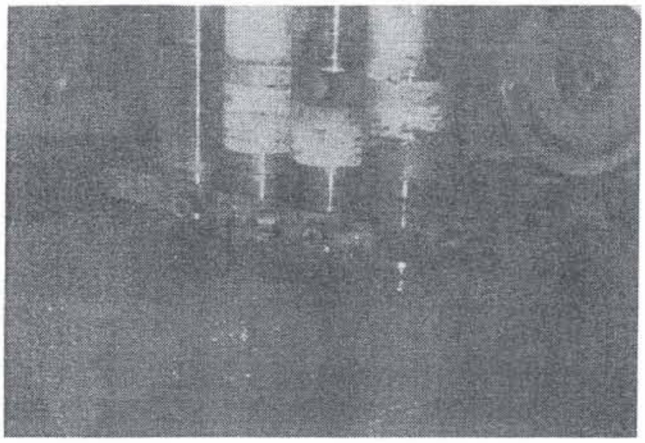

Fig. 3: Drilling device for the border semicilindrical elements.

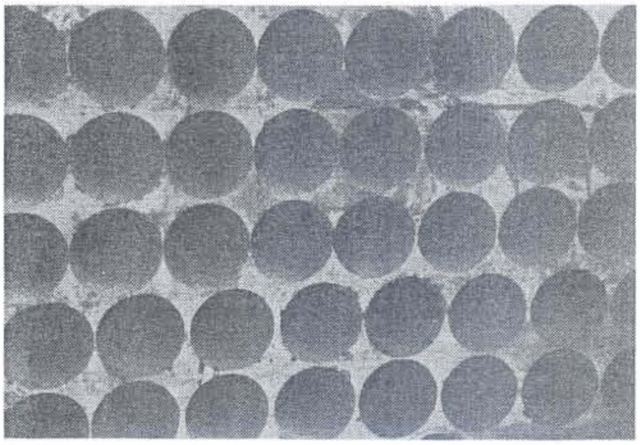

Fig. 4: Vaste reduction using the new drilling device.

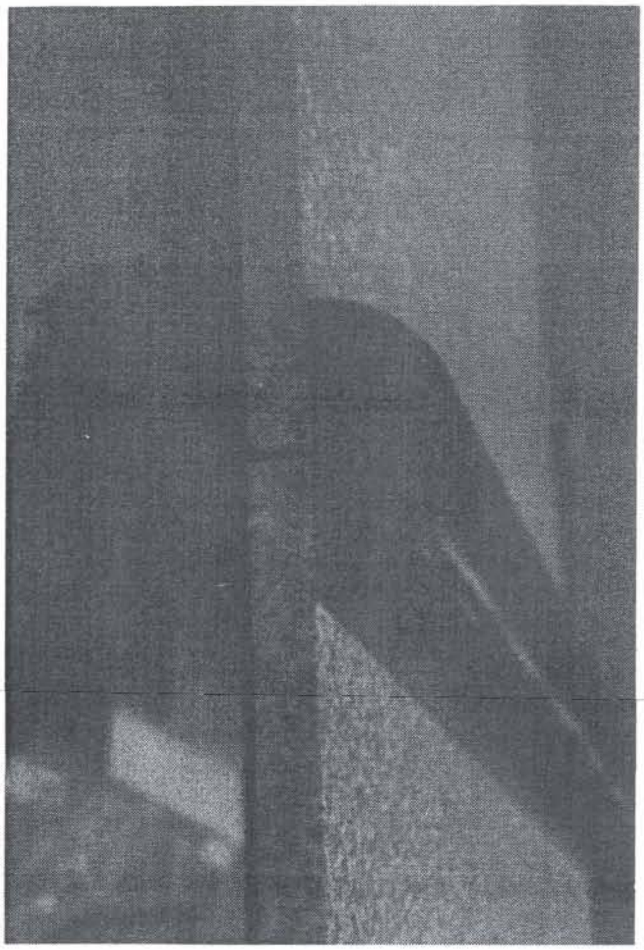

Fig. 5: Coupling of the grey »luna–perla« and the »Black Indian« granites.

A special lathe is emploied for polishing columns. Then columns are splitted in two halves, wich are the elements of the border (see Fig. 5). This manifacturing procedure allows to obtain extremely precise dimensions of each piece and unreduced strength of the material.

The Canary Wharf FC5–London

The stone cladding panel system is employed also in the »Morgan Stanley International Project«, at Canary Wharf FC5–London,* from the lower level to the 1 and 2 included.

Some draw and some photography will be presented to explain the basic design philosophy for the tipical facade panels (see Fig. 6,7 and 8).

The strong back metal frames for the column covers and the spandrel panels (see Fig. 9 and 10) are manufactured from welded rectangular hollow section profiles, zinc rich primer coated, providing a high degree of flexural – torsional stiffness to the frame construction on order to support he dead and wind loads.

The typical facade area from lower level to level 2 is divided in six preassembled blocks: the column cladding structures at the levels lower, plaza and 1st the arch plus parapet cladding structure at the three levels (see Fig. 11).

Fixed to these frames, all around, there are light weight horizontal profiles, supporting the stone cladding by small brackets.

Each spandrel panel is simply supported at the edges of upper horizontal profile of the steel frame and is restrained at the edges of upper and lower horizontal profiles it is also restrained at the steel frame center on the concrete slab.

Brackets are designed to allow free thermal movements fo panel frame.

The supporting brackets are fixed directly to the flanges of the perimetrical columns and are adjustable +/– 25 mm along the three axes and works like an hinge, while the restraint brackets are fixed on an imbedded channels into the span central axis of the floor concrete slab and on the column flanges under the floor slab; they are adjustable and work axially like hinged members.

The column cover panels are generally supported and restrained on the top and only restrained on the bottom to the steel column.

Stone anchoring system

Stone anchoring system is designed to allow free thermal movements.

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* project Skidmore, Omingse Merroe (New York) realization: Alpha (Massa-Italia)

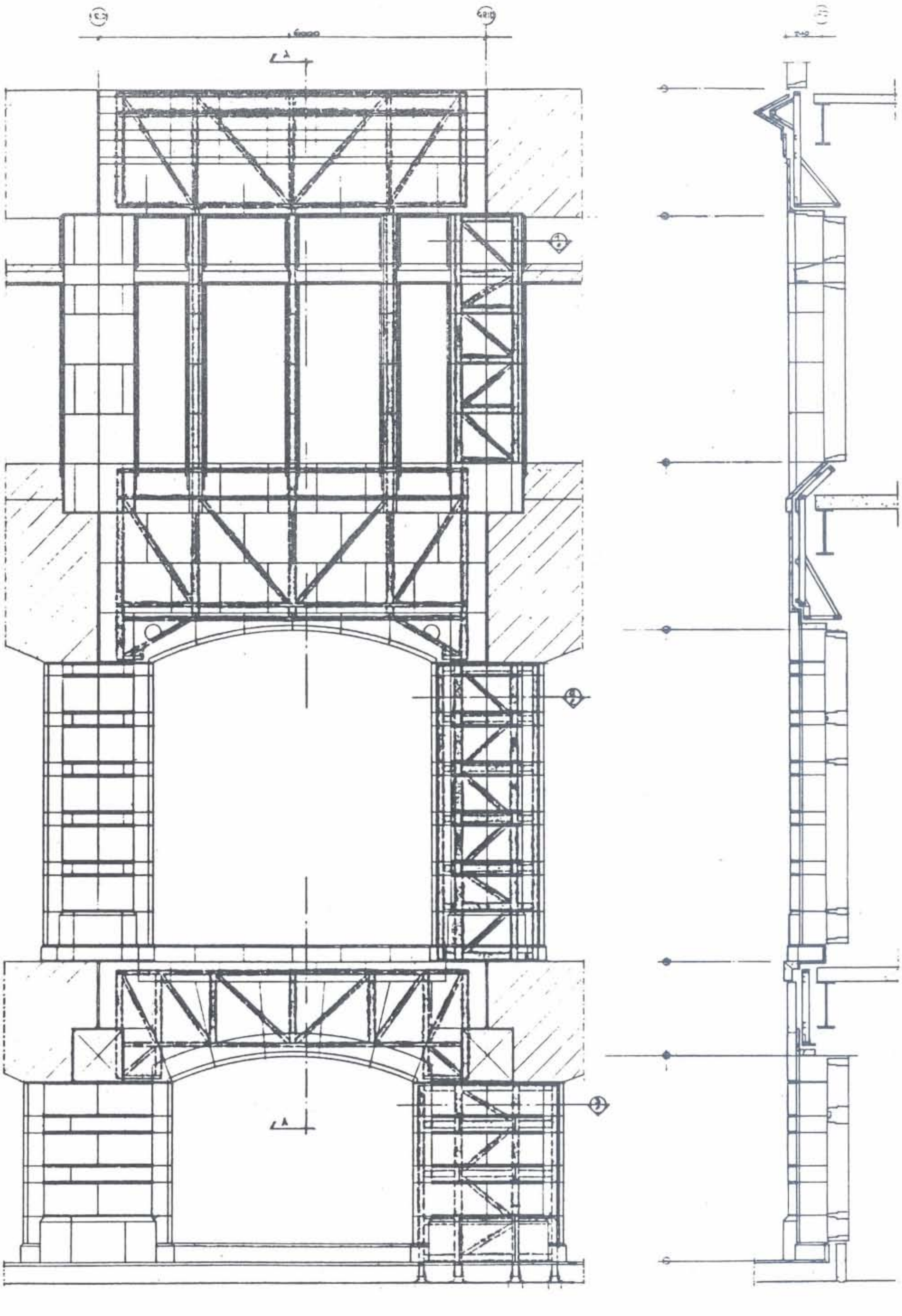

Fig. 6: Canary Wharf FC5 London. The module of basament. Front view and vertical section. The strong back steel structure is enhanced.

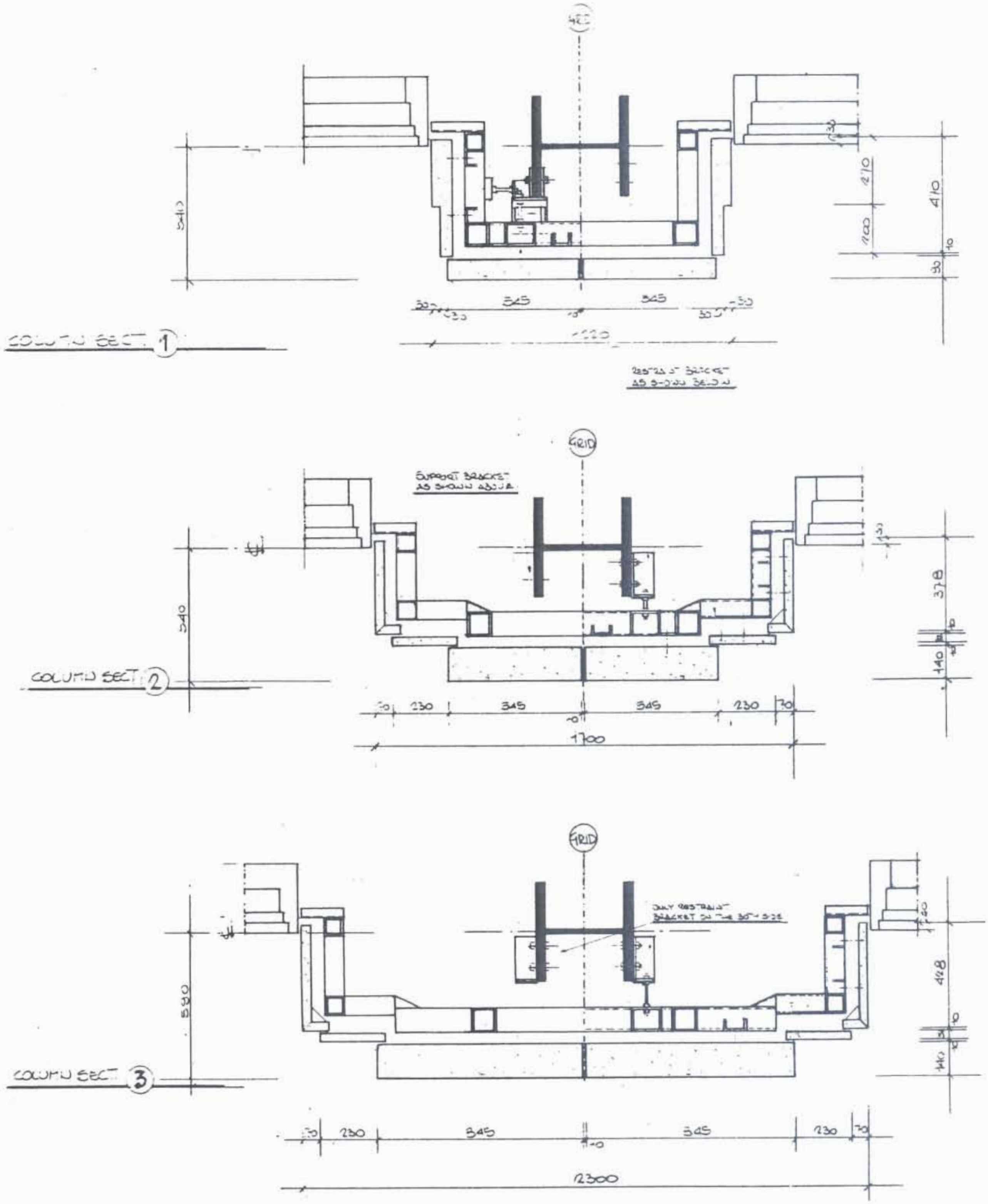

Fig. 7: Canary Wharf FC5 London. Horizontal sections of the column at first level, plaza level and lower level.

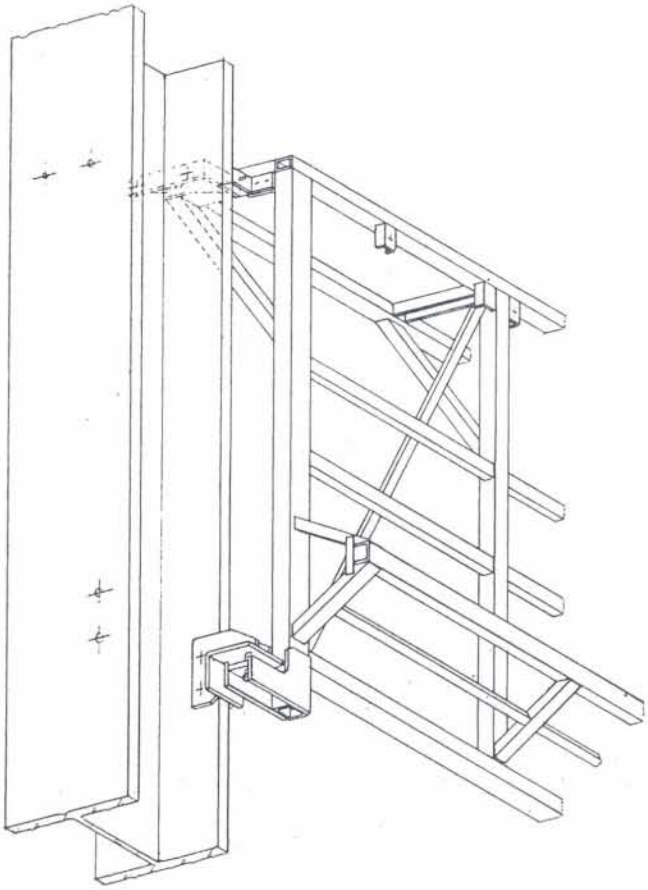

Fig. 8: Second level panel fixing system – axonometric view.

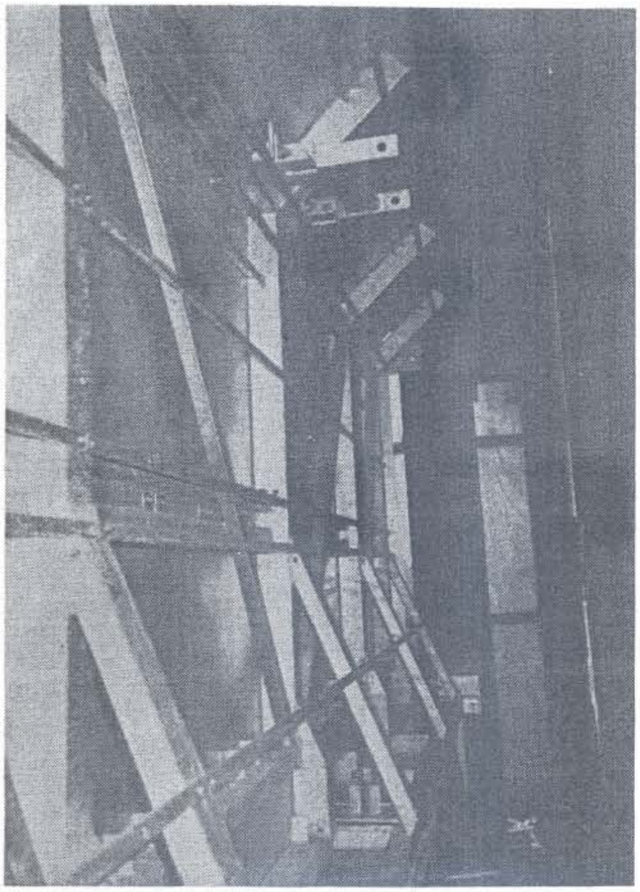

Fig. 9: Canary Wharf FC5 London. Plaza level arch cladding panel. Back view of the steel frame.

Fig. 10: Canary Wharf FC5 London. Plaza level – column cladding, steel frame back view. To be noticed the scheme of diagonal reinforcements to avoid stresses on stone sheets.

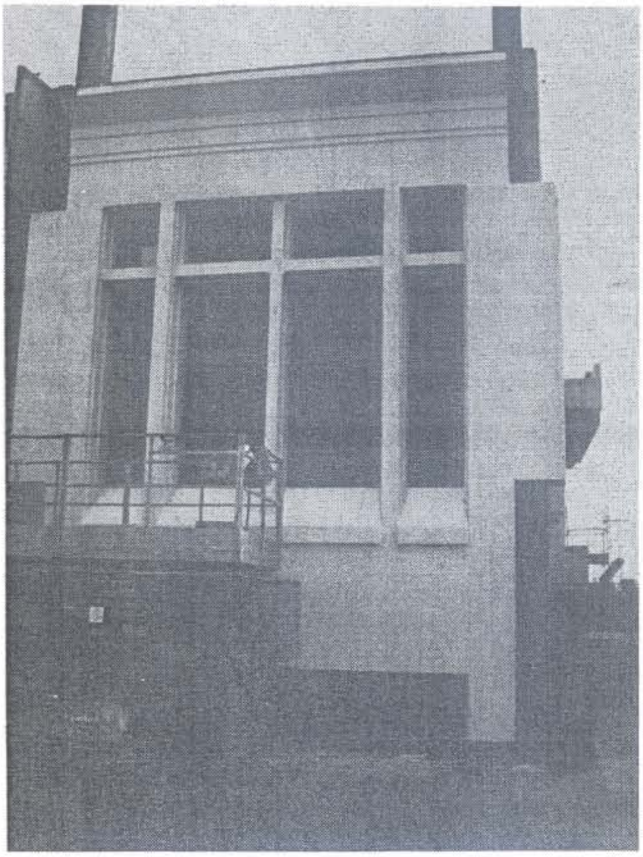

Fig. 11: Canary Wharf FC5 London. Large window at first level, composed of several levels, factory mounted.

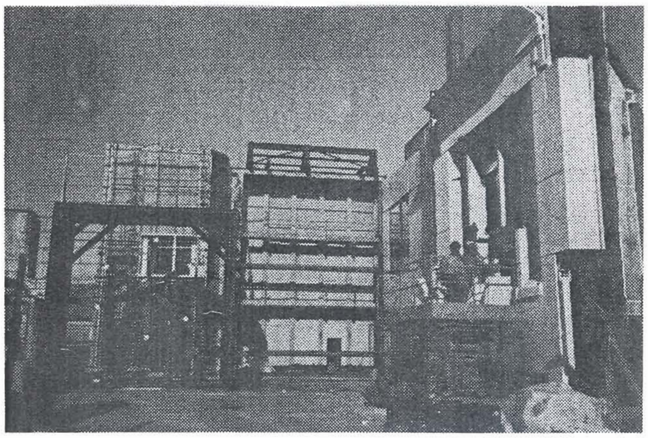

Fig. 12: Test site for wind and storm waterproofing. An airplane motor and propeller are employed for wind and storm waterproofing.

This system of panels is formed of several horizontal mild steel channels stringers, welded to the panel frames behind the moisture barrier, supporting all the stone clips (supports and restraints) made of steinless steel AISI 304, including fasteners.

All fasteners through the water barrier are galvanic separated from the carbons steel components by special plastic washers and rings while behind stainless steel clips on the galvanized water barrier ar protected by heavy epoxy painting, and sealed by silicon sealant.

Some special stone pieces are fixed by threaded pins epoxy glued holes on the back of stone.

Moisture water proofing barrier and flashing

The whole panel strong back metal frame is covered with a galvanized steel sheet, 0.8 mm. thick, air tightened in each joint and fastener penetration by silicon sealant.

The continuity between the water barriers of two adiacent panels, in front of building steel columns, is assured by 20 mm joint, job site sealed from inside, designed to allow panel differential movement. In this way it is possible to control and to repair joints between panel from building indoor during the building life.

At the bottom of the panel steel frame, below the water barrier, a stainless steel flashing will be installed going into stone vertical joints with drainage weeps (see fig. 12).

Conclusions

As for the behaviour of the materials and for the final effect of facing, factory prebuilded stone sheeting offers results wich are always better than on site, traditional building technology building facing, provided that the above proposed remarks are observed.

As for facing perfection, prebuilding allows much better results than traditional facing.

On the economic side, the technology of mounting panels from indoor allows avoiding large expensive scaffolding.

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Ponašanje kamenih pročelja u urbanim okolišima
Nove tehnologije građenja

A. Monaco

Izložena je nova tehnologija upotrebe arhitektonsko–građevnog kamena za oblaganje pročelja visokih građevina od željeznih i betonskih konstrukcija.

Prednost pri oblaganju pročelja objekata daje se granitu (u širem komercijalnom smislu) kao nesumnjivo superiorno otpornom kamenu prema trošenju u bilo kojim uvjetima onečišćene urbane atmosfere.

Tehnički problemi koji proizlaze pri upotrebi kamenih obloga na pročeljima građevnih konstrukcija i objekata jesu:

- uvjeti okoliša (brze promjene temperature, pritisak zraka i vlažnost),
- deformacije u konstrukciji građevine,
- naprezanja u kamenu uzrokovana eksploatacijom, preradom i ugradbom, te
- moguće akumulacije kondenzata u šupljinama čijim smrzavanjem mogu nastati pukotine u pločama kamena.

Da bi trajnost ugrađenih kamenih ploča bila zagarantirana potrebno je da ploče imaju takvu podlogu koja će onemogućiti bilo kakva unutrašnja naprezanja. Posebno se naprezanja skeleta građevine ne smiju prenositi na obložne kamene ploče.

Općenito, zbog niza razloga, za oblaganje pročelja objekata preferira se granit, iako je mramor nesumnjivo estetski izražajniji, ali u urbanim okolišima podložan oštećenju pod djelovanjem atmosferilija, prašine i dima.

»Klasični« način učvršćivanja kamenih ploča direktno na kostur građevine zamjenjen je ugrađivanjem izrađenih panela, čime se bitno smanjuju i eliminiraju štetni utjecaji skeleta objekta i onečišćenog okoliša.

Izložena su i opisana dva primjera oblaganja izrađenim panelima (Genova i London) s izvedbama učvršćivanja ploča u panelima, s posebnom izvedbom da se spriječi penetracija vode u kamenu oblogu.