Seminar:

A Review of Research in Masonry in Malta

Announcement

The Department of Building and Civil Engineering of the Faculty of Architecture and Civil Engineering of the University of Malta is organizing a symposium on the theme:

'A Review of Research in Masonry in Malta'

in July 1991.

Objective and Scope

The University has earmarked substantial resources for the upgrading of the Building and Civil Engineering Laboratories; and the Department of Building and Civil Engineering has already indicated that one of the main lines of research it would develop with these new resources would be the study of masonry structures. Globigerina or concrete block masonry is the major building material on the island, but has long been neglected, in Malta as in other countries, as a material worth studying, or worth "designing". In many countries, this has changed over the last decade, and it is hoped that it is also gradually changing in Malta. Since 1984, there have been a number of projects at the University which, although limited in scale and scope, because of the constraints of time and resources, can, in their totality, already serve to give a more scientific appreciation of globigerina limestone masonry.

The symposium will enable the presentation of the main results of this work, in a concise and clear way, to industry, so as to invite the profession to regard masonry in a more rational way, and to ask industry's support for a more organized, better directed, and better resourced programme of research.

It is intended that the papers submitted at this symposium will be published, so as to produce what would be the first reference document on the properties and behaviour of masonry.

Topics

The symposium will be organized around the following topics:

(a)   Mechanical and Physical Properties
(b)   Structural Behaviour
(c)   Analysis
(d)   Durability and Repair
(e)   Industry

Call for papers

You are being invited to indicate your willingness to take part in the symposium, and to prepare a paper on the work you carried out.

Schedule

-     Acceptance of participation by 30th May, 1991

-     Submission of photo-ready papers by ~th July, 1991.

-     Symposium, presentation of papers   31st July, 19 .

Symposium address

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Globigerina Limestone (Franka)
As a Structural Material

Introduction to Masonry Construction

Our building stone has always been used as a structural
material, even when other countries had discarded the
structural strength of masonry and used it only as
au infill material in between a concrete or steel frame.
We are fortunate in having a soft limestone that may be
easily dressed forming aesethically pleasant wall panels.

It is not unusual nowadays for an architect to be
commissioned to design a building 10 storeys high. The
most economical form of construction to be adopted is
a hybrid structure, with a concrete frame on the lower
floors and a masonry structure above. With these number
of floors, local masonry is being stressed to its limit.
It is now very important that the properties of our local
"Franka" be properly understood and researched, something
which in the past has been underrated.

What properties must a material have for it to be
classified as a structural one? The properties are:

(i)   load bearing capacity;
(ii) fire resistant properties;
(iii) durability performance.

At the turn of the century till past the middle of
this century, the trend in building has been in producing
a jungle of concrete buildings or a steel skeleton
hidden by a glass facade. An increase in research during
the past decade, helped by the energy crisis, have helped
the "Brick (masonry) is Beautiful" campaign. It is now
accepted that masonry forms an attractive durable cladding
with good thermal acoustic insulation, excellent fire
resistance, plus it is an economical structural material

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that can be built faster, cheaper and more easily than
its rivals, steel and concrete.

Of the properties mentioned above concrete suffers
from durability. The matrix of steel bars and concrete
creates corrosion and spalling problems. Many eminent
engineers have been made to blush during their lifetime,
not due to errors in structural calculations, but due to
the deterioration of concrete buildings or bridges. They
are being maintained, but concrete repairs is a very
expensive item, not envisaged as part of the required
maintenance during the design stage, reducing the expected
rate of return for the developer. Our university is
facing such a problem as concrete columns instead of
masonry peirs were used in its covered walkways under
existing buildings. Concrete repairs are being done to
these spalled columns, a building not much older than
twenty years. Our Churches and palaces built 400 or more
years ago, are proof of the good durability properties of
our local Franka.

Steelwork has low fire-resistance, demonstrated by
the tragidy of the Main Hall at the Conference Centre.
Specialized labour is required to erect a steel-frame.
Ignoring fabrication time it is true that a steel frame
has a short site erection time, but no other construction
work can take place during the erection period. This is
not the case with masonry structures where there is a
continious follow of other trades.

Large open space structures, such as factories, sports
halls, hangars, etc., have traditionally been constructed
in a steel or concrete portal, with infilling sheeting
or masonry. With the development of new structural forms
in masonry diaphram or fin walling, the roofing system
may now be supported directly on to masonry. The struc-
tural form of masonry adopted, catering for all the
vertical load and wind forces. This efficient and economical

form of construction can provide the structure, the cladding, and insulation in one material erected by the main contractor using only one trade.

A disadvantage in using masonry could be an increase in the obstructed area over steel or reinforced concrete. There is no reason why piers in department stores or similar structures are not constructed in masonry having a higher compressive strength. Lower coralline limestone has a very good compressive strength, but weak in tension. Reinforced and post-tensioned masonry may be used successfully where tension develops. Such structures are retaining walls, silos etc.

The masonry arch was a very important structural element, spanning large distances. Before the advent of steel work, the first railway bridges were masonry arches. Masonry arches then went out of fashion and the theory of arches was almost forgotten. Further advances in the theory of arches were evolved during the past wars, as checking of these arches for heavier loading was required. Today there is an awakening and also a revival of interest in the old structural form of the arch. Presently research work is being carried out on the limit state design of masonry arches (1), a method which will facilitate the tedious arch calculations. This may revive the demand amongst architects for arched ceilings due to their aestethic appeal.

The composite action between masonry panels supported on concrete beams (2), should also be investigated as this will effect greater economies. A hotel block is normally a hybrid structure, the upper bedroom floors constructed in masonry, whilst the ground floor being the foyer requires large open floor areas supported on a concrete frame. The concrete beams and upper masonry walling are not to be designed as seperate elements, but as a composite structure. The whole unit is to be designed as a deep beam, with the reinforcement in the concrete beam taking the tensile forces and masonry

walling above taking the compressive forces. In this
way the lever arem is increased with a corresponding
decrease of steel required.

Well designed structural forms in masonry are most
robust and more resistant to progressive collapse due to
the inherent arching capabilities of masonry than other
structures. For high rise buildings the plan layout
should be disposed to give a high rigidity against
horizontal wind loading. An example is the 8 stories
Qawra Point Block.

Geogolical Date on Franka

"Franka", the local building stone is obtained
from the lowest bed, of the three distinct beds of
Globigerina limestone, each bed being seperated by a
phosphorite conglomerate horison. Globigerina limestone
outcrops mostly in the south-eastern part of Malta, cover-
ing approximately two-thirds of the surface area. From
the geographical map published by Pedley et al it may
be noted that the outcrops of Globigerina limestone are
mostly of the lower bed. Its maximum tickness is about
300 ft. The quality varies along this depth and at
approximately every 40'0" a "sol" layer is encountered.

The whole strata has been formed organically by
the deposition of calcium carbonate, from the cementing
together on the sea-bed of the shells of Globigerina and
other Foraminitera. The calcium carbonate content varies
between 65% - 95% and traces of iron oxide exist in some
deposits. It is not strongly bedded, hence its name
Freestone ("Franka").

From microphotographs of a thin section of Globigerina
limestone, one may notice the similarities in pore struc-
ture to Portland Stone (U.K.). It is probable that
good quality "Franka" would be acceptible for use in a
more aggressive environment, as that in the U.K.

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Nowadays quarrying is carried out in the Tal-Balal area l/o Naxxar & Mqabba area, comprizing Siggiewi, Mqabba, Kirkop & Qrendi.

(1) Load Bearing Properties of Franka

Masonry is a composite material. Its strength is dependent on the crushing strength of the masonry block and of the infilling mortar used. It also depends on the workmanship. The most common workmanship defects are:

(1) The horizontal bed joints should be filled completely with mortar. Incompletely filled bed joints may reduce the strength of masonry panels by 33%. Failure to fill vertical joints has little effect on the compressive strength but are undesirable for weather exclusion and sound insulation.

(2) Mortar bed joints should not be thicker than 12mm ($\frac{1}{2}$"). Bedjoints of 16-19mm thickness, result in a reduction of compressive strength of up to 30% as compared with 10mm thick joints.

(3) Before laying mortar the block is to be well wetted to reduce its suction rate, plus a proportion of lime in the mortar mix will help the mortar mix to retain its water. A high absorbent block will result in a weaker mortar, with a resulting weaker wall panel.

The relevant code of practice for structural masonry (3), after taking into consideration masonry unit strength, mortar strength and degree of workmanship available gives values for the compressive strength of masonry panels.

From tests carried out by J. Cachia (4), on local masonry blocks, collected from various quarries, the highest average crushing value on a dry sample was 32.9 N/mm^2 (4750 1 bf/in^2) whilst the corresponding lowest was 15N/mm^2 (2175 1 bf/in^2). The highest value was

obtained on a "sol" sample. The sol sample was the
densest and had the lowest void ratio and porosity.
When tested in the fully saturated state the compressive
strengths obtained were on average 39% lower. One
may assume internal walling to have dried to its dry
state, whilst for exposed walling an intermediate value
is to be taken for the fully dry and completely saturated
state. When blocks were tested normal to their bed
of stratification the strength was higher than for
blocks tested with their face parallel. The difference
ranged from 0% to 21%, the average works out at 8%.

From a different source (5) the crushing strength
of Coral limestone is given as $75N/mm^2$ (11,000 lbf/in^2).

From tests carried out by W. Debattista (6) on local
mortars the commonly used cement mortar mix having
proportions 1:2:10 of cement, to coralline limestone
sand to fine globegerina sand had an average crashing
strength at 28 days of 1.85 N/mm^2 (265 lbf/in^2). A
stronger cement mortar mix having proportions of 1:2:6
had an average crushing strength of 28 days of 4.5N/mm^2
(650 lbf/in^2). He also carried out tests on lime mortars
and a composite cement, lime mortar. The results obtained
demonstrated that lime mortars were superior with regards
to water retentivity, consistence retentivity, air content
of freshly mixed mortar and flow. On the other hand
cement mortars have a higher flexural and compressive
strengths, together with a longer setting time. The
composite lime-cement mortar, exhibited intermediate
workability and strength characteristics. The reintroduction
of lime into our mortar mixes is to be encouraged due to
better properties achieved.

With reference to the Code of Practices on structural
masonry$^{(3)}$, the following information is given:

4 mortar types are defined according to crushing
strengths achieved after 28 days.

Type   (i)   having a strength of 16 N/mm^2

         (ii)   having a strength of 6.5 N/mm^2

      (iii)   having a strength of 3.6 N/mm^2

       (iv)   having a strength of 1.5 N/mm^2

So our 1:2:10 mortar mix is classified as type (iv) mortar, and the 1:2:6 mortar mix classified as type (iii). In reinforced masonry work, ref (3a) suggests the use of mortar type (i) and (ii) only, showing the importance of the use of high strength mortars.

As stated previously the compressive strength of a wall panel depends on a combination of the respective mortar and masonry unit strength. The greater the proportion of mortar/unit area of block, the lower the strength of the wall panel. The code of practice [3], therefore gives different values for 6" or 9" masonry units.

The following 2 tables derived from the Code of Practice [3] give wall panel strengths for a given masonry block and a given mortar designation.

TABLE   1   -   Estimated Compressive Strength of Masonry for 9" blocks (n/mm^2).

Mortar Designation	Compressive Strength of Unit N/mm^2			
	Globigerina			Coralline*
	18	20	23	75
(i)	9.5	10.3	11.4	26.3
(ii)	8.2	8.9	9.7	20.8
(iii)	7.6	8.0	8.8	18.0
(iv)	6.8	7.2	7.8	15.2

TABLE 2 — Estimated Compressive Strength of Masonry for 6" blocks (N/mm^2)

Mortar Designation	Compressive Strength of Unit N/mm^2			
	Globigerina			Coralline*
	18	20	23	75
(i)	12.3	13.3	14.7	34.4
(ii)	10.7	11.5	12.6	27.0
(iii)	9.9	10.4	11.4	23.4
(iv)	8.9	9.3	10.0	19.3

* Value for coralline wall panels were extrapolated from Code of Practice [3], as a block having such a high crushing strength is not quoted, but quoted in ref (3a) and values obtained agreed.

The values of the ultimate strengths of wall panels are to be divided by the relevant factor of safeties to obtain the alloweable working load. An average value for load is 1.5, whilst for material strength with average workmanship a value of 3.0 is quoted. So the global factor of safety to be used is approximately 4.5.

Tests on 26 different 1/3 scale wall panels have been crushed to destruction by P. Buhagiar (7). Masonry blocks used were from 3 different quarries having different strengths. The Mqabba blocks had an average of 20N/mm^2, Naxxar blocks had an average of 22.5N/mm^2, whilst the Siggiewi blocks had an average of 17N/mm^2. 2 mortar mixes were used, a cement mortar (1:3:12) having a crushing strength after 28 days of 1.75N/mm^2 (type (iv)) and a composite cement lime mortar (1:1:2:4) having a crushing strength after 28 days of 5.9N/mm^2,(type iii). The greatest variation from the code of Practice [3], were on the 6" blocks. Another anomaly was that the blocks from Naxxar quarry, with the highest crushing strength, achieved the lowest wall panel loading. By

further tests conducted by P. Buhagiar (7), this is
attributed to a high initial rate of absorbtion, which
as mentioned earlier on, would affect the mortar strength.

Buhagiar (7) concludes that the same strength should
b used for the 6" and 9" local masonry blocks, disregarding
the higher values attributed to the 6" masonry blocks.
A 6" thick unit is more slender than the 9" unit, so
could not have slenderness effects reduced the crushing
load? It must be borne in mind, that during the tests
the mortar beds were fully filled, which does not always
occur in practice.

From the above, it may be concluded that for preliminary
design calculations a masonry block, having a crushing
strength of $20N/mm^2$ (2900 lbf/in^2) may be adopted.

(ii)   Fire-Reisitance of Franka

The temperature rise at any particular depth below
the surface of a wall exposed to fire depends on the
intensity of the fire, on the period of exposure and on
the thermal diffusuity of the material. The intensity
of fire in a store with inflammable materials, would
be higher than that inside a church. Building stones
have a low thermal diffusuity. Hence the rate at
which the temperature rises within the body of the wall
is correspondingly slow. This high temperature would
not exist within even a moderate depth below the surface.
This difference in temperature between the outer and
inner parts of masonry creates a steep temperature
gradient which may cause cracking or spalling. It is
damage of this kind that calls for repairs, mostly in
columns, window-jambs, cornices, sills, mouldings, and
similar projecting features.

For temperatures up to 400°C, heat causes the develop-
ment of a pink or reddish-brown colouration, for Franka

containing iron-oxide. For Franka free from iron-oxide
it becomes greyish in colour. The depth of this colour-
ation seldom exceeds a depth of ½". At higher temperatures,
in the region of 600°C, the colour disappears and calcination
starts. Calcination involved the driving off of carbon
dioxide, from the limestone calcium carbonate and leaves
a residue of calcium oxide or quicklime. Considering
the width of the coloured stone, referred to above and the
temperatures indicated, it is not to be expected that
there should be any considerable degree of calcination
of limestone in a building fire. Calcined limestones
have a dull, earthy appearance, differing from the
original limestone.

It has been proved that there is no significant
reduction in crushing strength of limestone for tem-
peratures up to 400/450°C. Thereafter the strength
decreased and at 600°C the masonry retains 60% of its
original strength (8). Since in a building fire, the
effects are confined to the outer layers, no serious
loss occurs to the strength of the masonry unit. But
in staircases, which are stressed in tension, it will
be better to rebuild any masonry staircase, exposed to
fire unless it can be shown otherwise by loading tests.

It is usually considered safe to rebuild on existing
walls, after considering the effects of any lateral
movements of masonry wall induced by thermal expansion
or stresses resulting from collapse or partial collapse
of roof or walls. It is also to be ensured that no
future damage exists from falling fragments.

(iii) Durability of Franka

There are many fine buildings which have been
erected over 400 years ago and are still in a structural
safe condition. St John's Cathedral and the Auberges
are proof of this. But even in the same buildings,
it is noted that some masonry units weather to a different

degree than others. It may be due to its position.
Sills, balustrades, stone courses between ground level
and d.p.c. and coarses immediately below a cornice
are known to deteriorate more than masonry in other
locations. The reason for this faster deterioration
may be due to causes such as being exposed to weather
on all faces for balustrades, or being sheltered from
the wash-down effect of rain on courses below a cornice.
But when in a wall panel there exist masonry units with
different deterioration effects, then the cause must
be due to the internal matrix composition of the franka
unit. In this case, tests will be required for the
selection of better quality Franka.

Exposure tests carried out by the Building Research
Station in 1958(9) have shown that franka is susceptible
to salt attack. The closer the masonry is to the sea,
the specified masonry ought to have a higher durability.
Terraced house built about 40 years ago, on the B'Bugia
sea-front, have badly decayed masonry. The probability
is that masonry was supplied from a nearby B'Bugia
quarry, which tests have proved to be of an inferior
quality. A good damp-proof membrane, is a requisite,
as salts from the ground are also known to cause deter-
ioration. An interesting fact is that rock-faced stone
(gidra) deteriorates less than fair-faced stone.

From the same work carried out in 1958 (9), it
was concluded that any sulphate attack on the stonework
through atmospheric pollution was small and of little
consequence. Is this true nowadays, if one considers
the Hamrun/Marsa area being subjected to pollution due
to the burning of coal for the power station? The
principal acid products of the combustion of coal are
carbon dioxide and sulphur dioxide. Carbon Dioxide
exists in the atmosphere and its effect on limestone
masonry is considered to be of relatively little consequence.
The production of acid sulphur gases by the combustion
of coal is more important. Coal contains on average
1 - 2% of sulphur, which on combustion is oxidised to

sulphur dioxide or sulphur trioxide, which in contact
with water forms sulphurous and sulphuric acids. Not
all the sulphur escapes into the air, some remains in
the ash or the chimney soot, neither does all the sulphur
dioxide which escapes, enter into combination with lime-
stone in buildings. Nevertheless, actual damage is
caused, its severity will have to be ascertained by
future tests. Soot deposits cause disfiguration and due
to acid materials which it brings into close contact
with the Franka under projecting features, accumulating
into thick black incrustations also causing chemical
disintegration.

Due to "Franka" not being strongly bedded, the
difference in weathering due to units placed on sides
differing from its bedding plane is not so marked, but
varies according to quality of masonry. The better type
of Franka showing slighter or no difference.

The building Research Station, have a standard
method of examination, for the selection of natural
building stone (10). Below are listed a number of
tests, which ought to apply for our environment and type
of stone. In 1958 [9] [5] a limited number of tests were
carried out on Franka samples together with further
tests in 1958[4] and results are discussed.

Limestones have a broadly similar chemical composition.
Chemical analysis is of no use to durability assessment.
It is the internal structure of a limestone rather than
its composition, that gives the clue to durability.

Indirect Measures of Pore Structure:-

(1) Porosity is the volume of pores within a stone, expressed
as a percentage of the total volume. It is conveniently
measured by vacuum saturation with water. Values range
around 10-20% although may be as low as 10% and as high
as 40%. The value for Franka samples was around 35%.
A 'sol' sample gave a low 27.8%[4]. Values for Coral

limestone are in the region of 10%[5].

Porosity gives no indication of the way the pore
space is distributed whether there are many fine pores
or otherwise.

(2)   Saturation co-efficient is measured by drying stone
used for porosity test. It is then soaked in water for
24 hours. The saturation co-efficient is the proportion
of pore space that becomes filled with water during
soaking. Values range from 0.4 - 0.95, the high value
indicating a high proportion of fine pores, being a
stone of low durability whereas a value of 0.4 would be
a stone of high durability. The value for Franka samples
was around 68%, being a grey region as on its own the
saturation co-efficient is an unreliable guide to durability.

(3)   Microporosity is the proportion of the total pore space
of pores having an effective diameter less than 5 microns. A
stone with high proportions of very fine pores is less
durable than a stone that has mainly coarse pores. The
two methods most widely used for the distribution of
pore sizes is the mercury porosimetry and the suction
plate technique. The underlying principle, being that
the pressure required to force mercury into an empty
pore (or suck water out of a full pore) is dependent
upon the size of the pore. The value for Franka samples
fell between a grey middle of 50 - 80%, which on its
own merit may not be used to classify its durability
characteristics.

An improved indication of durability may sometimes
be obtained by combining two properties.

For the Franka samples tested it was concluded[5]
that a wet/dry compressive strength ratio of 0.58 appears
to mark a dividing line between a better and a poorer
stone. This value appears to be confirmed also by tests
carried out by Cachia[6] comparing his values of wet/dry

strengths with his description of the respective quarries.
One anomaly appears in an Mqabba quarry which is described
as of poor quality masonry, but the wet/dry ration works
out at 0.7. The tests on this sample were carried out
perpendicular to bedding plane not normal to bedding plane
as in the other tests. Could this be the reason for
anomaly?

The dividing line between a very poor sample (0.56)
and a very good sample (0.59) is too fine and a better
indication of durability appears to be obtained by
dividing the wet/dry strength ratio by microporosity
and multiplying the result by 105. A tentative value
has been established at 1050[5]. More tests are required
to confirm this result.

DIRECT TESTS OF DURABILITY:

Direct tests are intended to subject the stone to
the same condition that it will encounter in use, but
in a more aggressive form.

The Crystallisation test is one. A stone sample
is subjected to cycles of immersion in sodium sulphate,
followed by drying in an oven. The test is comparative
and the loss in weight obtained must be compared with
the result of a standard stone, known to have good
durability characteristics. For the Franka samples
tested, the change in weight was between 20 - 30%, with
a poor sample being as high as 49%. A high proportion
of micro pores, together with a high loss in weight due
to crystallisation test, indicates stone to be less
durable.

PHYSICAL PROPERTIES AFFECTING DURABILITY:

When a material is exposed to the sun, the surface
becomes hotter than the underlying mass that is a
thermal gradient is set up in the material. On the
contrary, at night, radiation causes the surface to

become colder than the material beneath it. These
temperature differences cause unequal expansion, and
thus set up stresses in the material. The propogation
of temperature through a material depends on its thermal
conductivity and on its heat capacity, and the relation.

Conductivity/Heat capacity per c.c. is known as the
diffusivity. Unlike metals, building materials have
low thermal conductivities and relatively high specific
heats, hence their diffusivity is low and the stresses
correspondingly higher than they would be in materials
of higher diffusivity. But the temperature gradient,
set up in normal circumstances is unlikely to be a
serious consequence.

With certain building materials, changes in their
moisture content result in changes in volume. This
swelling on wetting results in shrinkage on drying. Such
types of material, would be less desirable to be used on
an exposed facade. The moisture expansion of limestone is
negligable and so no precautions are necessary to avoid
shrinkage cracking. Shrinkage cracks are visible where
a building built in Franka abuts against one built in
concrete blockwork.

The linear co-efficient of thermal expansion of
limestone is also low, so expansion joints are not required
on moderate lengths of Franka walling.

NEED FOR CLASSIFICATION OF QUARRY SITES:

It is a fact that the quality of local Franka varies
as it is a natural material. Franka is used exactly
as it is found, there is no processing or manufacturing
involved, which may change its quality. However, the
customer ought to be advised in his selection. For
instance, Franka used in an inland location, such as
Rabat may not be suitable for use on the Sliema sea-front
due to the deleterious action of the sea-spray. Nor is

it suitable in the Marsa area because the pollution there,
produces harmful acids. The franka used on the wall
panel of a facade may not be suitable for the balcony
balustrading or the overhead cornice. Ideally, the Franka
obtainable from a quarry, should be graded according to its
durability. A list should be compiled indicating the suit-
able use of Franka from a particular quarry, taking into
consideration its durability, the environment where the
Franka is to be used and its location on the building fabric.

Having convinced ourselves of the favourable prop-
erties of Franka, then we must use it as a truly struc-
tural material, not as an infilling wall panel. Its
obvious use is as a wall panel transmitting loads vertically
downwards, but its geometrical layout may be utilized to
transmit horizontal wind or earthquake forces to the ground.
In shed buildings, fin or diaphram walling may be used for
the side and gable walls. Reinforced masonry may be used
for retaining walls, whilst post ensioned masonry, extending
the structural capabilities of masonry is yet to be taken
advantage of, in Malta. The above mentioned methods are
more economical locally, besides providing less costs in
use expenses, when compared to other more evolved structural
systems. Developing the structural uses of Franka would
also lead us towards an improved architectural design, as
then Franka would be more functional.

References:

(1) Professor Heyman - Masonry Arch Design
(2) P.H. Wood - Studies in Composite Construction
(3) BS 5628 structural Use of Masonry pt 1 Unreinforced masonry
(3a) BS 5628   "   " "   "   pt 2 Reinforced & Prestressed
                                                          Masonry
(4) Cachia J. (1985) The Mechanical & Physical Properties of
     Globigerina Limestone as used in local Masonry Construction
     (Unpublished B.E. & A.(Hons.) Dissertation.
(5) BRE - Note C965
(6) Debattista W. (1985) Masonry Mortars (Unpublished B.E. & A. (Hons)
                                                          dissertation).

(7) Buhagiar P. (1985) Structural Masonry; experimental
determination of the compressive strength of a wall
(unpublished B.E. & A. (Hons.) dissertation).

(8) BRE - Note 21 The Repair of Stone-Work Damaged by Fire.

(9) BRE - Note B133 The Maltese Islands, use of Limestone for Building.

(10) BRE - The Selection of Natural Building Stone.

D. H. CAMILLERI

Structural Consultant

Job No.	Sheet No.	Rev.
XX91	Appendix A	

Member / Location LOAD ANALYSIS
Drg Ref.
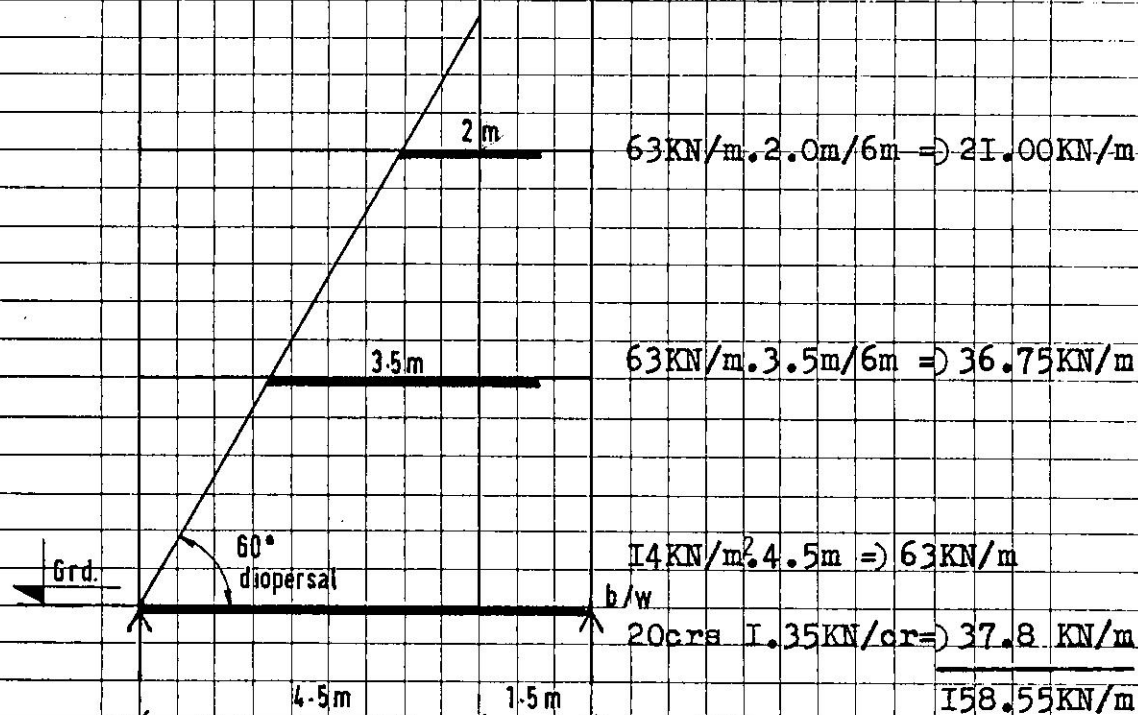Made by DHC   Date JULY 91   Chd.

Job Title   GENERAL

BEAMS AT GRD. FLR
at 4.5 m ∉
DESIGN LOAD taken at
14 KN/m^2 to cater for
TRANSVERSE PARTITIONS

2 m   63KN/m.2.0m/6m => 21.00KN/m

3.5m   63KN/m.3.5m/6m => 36.75KN/m

60° dispersal

Grd.

14KN/m^2.4.5m => 63KN/m

b/w   20crs I.35KN/cr => 37.8 KN/m

158.55KN/m

4.5m   1.5m

B.M(beam) => 158.55.6^2/8 => 713.47KN-m

Calculation by method proposed by Wood (8)

loadings from upper flrs. + b/w

(14KN/m^2.4.5m + 11crs.1.35KN/cr 1.4) 4flr => 335KN/m

B.M => 63.6^2/8 + 335.6^2/40

=> 585KN-m

The 2 values for B.M equate for a 6 storey building.