**MASONRY CONSTRUCTION & STRUCTURAL ENGINEERING**

The good thing about masonry design is that it may be undertaken by means of hand calculations, no need for software. Masonry design involves basic structural engineering principles which truly impart the engineering feel to the end user.

Masonry design goes from vertical loading, incorporating slenderness effects, eccentricities on the bearing, all of which may be undertaken via simple statics. 3-pinned arch design may sort out bridge loading or else utilised to sort out horizontal wind or soil loadings on wall panels. Then stability problems are introduced via wind/seismic loading, with the positioning of shear walls according to structural engineering principles.

An introduction to masonry design will set you on the right structural engineering path. The initial concept of structural masonry is that it is a composite material - composed of the masonry block together with the bonding mortar. The compressive strength of a masonry panel is thus dependent on both the masonry and mortar strength.

Going onto reinforced masonry, new concepts are further introduced due to the presence of mortar. It is found that anchorage and lap lengths in reinforced masonry can be much longer than the respective lengths in reinforced concrete, as in some instances the bond strength of mortar has to be utilised. This can introduce a buildability issue as lap lengths higher than 100 times the diameter may be necessary.

The options appear endless, pity universities stick to the more traditional structural materials where the structural codes nowadays abound in complications & students generally lose the wood for the trees.

Cases can arise, although possibly infrequently, where the architectural design, does become too adventuresome. This is where the builder is not sufficient for the architect, who then will assume risks beyond his capability and the structural engineer has to kick in. These adventuresome designs can provide serviceability issues, such as cracking to brittle partitions. This may be averted by limiting the deflections of the supporting slab to have span to deflection ratios exceeding 500. The present building user is more averse to cracking than previously. This ties in with the recent notes on professional indemnity as published in The Structural Engineer, as professional indemnity claims are on the increase.

Now here is the crux, the structural engineer has to be capable in designing to masonry. Unfortunately as noted above, it is not too frequently undertaken in undergraduate courses.

The structural engineer has then to undertake masonry design on his own steam. The advantage as mentioned earlier is that he will gain in what is defined as engineering feel. Previously this feel had been obtained from steelwork design, but now masonry is considered a better alternative, as unfortunately steelwork has gone down the high complexity route, which presently masonry has steered clear of.

Now Europe in its historic centres has mainly been adverse to high rise constructions, this unlike America & Asia. Residential buildings in historic centres are noted to be mainly limited to 8 storeys in height, is this a coincidence?

EC6 appears to refer to a maximum building height of 24m (8 stories) together with a maximum storey height of 4m. This may probably be inferred by referring in combination to Cl 5.3 (2) in EC6-1 together with figure 3.1 in EC6-2. Workmanship Cl 9.1 which then refers to EC6-2 is also of relevance. Have the apparent above EC6 limitations be guided by the historic European constructions referred to?

Now further to the structural principles referred to above EC6 includes for fire protection, durability requirements and touches on weather tightness. Further masonry design nowadays has to incorporate co-ordination with building services, whereby the amount of chases imposed on the masonry fabric is much more intense than previously. This is again tackled by the masonry Eurocode and its recommendations on vertical, horizontal and inclined chases should be incorporated in the project's specification document, to control the chasing as undertaken by these works.

Why should structural engineers not be versed in aesthetic ratios, reverberation characteristics of masonry spaces together with the economic aspect of designing in masonry. Was not structural engineering referred to as designing in elegance and economy?

**AESTHETIC BEAUTY, PROPORTION & HUMAN SCALE, ACOUSTICS & ECONOMY:**

This refers to a commensurable system of proportions 1:2, 2:3 and 3:4 mostly related in the major scales of western music. Incommensurable system of proportions 1: 2, 1: 3 and 1:Ø (golden ratio = 1:1.618).

If a structural engineer is commissioned to design an assembly hall of plan dimensions 6m X 10m, what proportion of the plan dimension should be utilised to advise his client to achieve an aesthetically proportioned ceiling height. Having established the volumetric proportions of the designed space then the structural engineer by undertaking simple reverberation checks should be in a position to advise his client whether this masonry enclosure will require further the services of a sound engineer.

Was not the master builder, the Victorian engineer the precursor of the modern structural engineer? Once the Romans realised the potential of an arch, this concept released large open spaces as noted in the enclosed Roman Baths, resulting then in the basilica of Istanbul's Hagia Sophia. These large spaces followed by the Gothic Cathedrals were undertaken by master builders that guarded their principles. Principles that were mostly dependant on proportions, whilst adhering to low masonry stresses. Reverberation of gothic cathedrals was considered an improvement to the previous basilica type constructions.

In Malta said to house baroque churches that count as many as one for each day of the year, together with the innumerable countryside chapels, Auberges and similar masonry limestone heritage buildings was also undertaken by a master mason, who during the time of the Knights of Saint John could have been elevated to a perit *(the Italina word perito refers to an expert)*,. A numerus clausis was imposed at the time, with the number limited to 12. A mason could only be elevated to a perit on the death of an acting perit. This master mason perit, was the persursor of Malta's professional perit with the present remit of architect and civil engineer, with the Kamra tal-Periti as established in 1921.

Finally the Aesthetics of a structure is the outcome of the Social, Cultural, Geographical and Economic Contexts. Did not the Victorian engineers impart aesthetics in the design of the masonry bridges carrying the railway, together with the aesthetics of the 3-pinned steel impressive structures for the opening up of the train stations? The structure will be realised if Costs fall within an allocated budget. Engineers study the variation of Cost with respect to the Shape & Proportion to design structures with Aesthetic qualities within an allocated budget.

It is noted that some cost data is provided for in the Institution's Concrete Handbook, but apparently strangely none is mentioned in the Steelwork Handbook. If the economics of masonry construction is to be advanced, some easily undertaken cost data info will not be amiss.