REPORT ON USE OF PELLETIZED EXPANDED SLAG IN STRUCTURAL CONCRETE

42-Story "Century Twenty-One" Building In Hamilton, Ontario by R. P. Cotsworth, National Slag LTD

Soaring 400 ft. above ground level, the tallest building in Hamilton, Ontario, population 300,000, will be Century Twenty-One when it is completed in the fall of 1973. This structure will tower over all others in the newly re-developed downtown core. The building will extend a full 42 stories, of which there will be an eventual six floors of shopping, four floors of prestige office space and a distinctive gourmet restaurant on top. The balance of the building will be permanently occupied by families in luxurious apartments, many of which will be custom styled to suit the taste of the occupants. Another feature will be a heliport capable of whisking visitors to nearby airports.

Upon learning of the proposal to construct this building, we approached the architect - Munro-Ploen & Associates LTD - and the structural consulting engineer - Omen Lee & Associates - requesting that semi-lightweight pelletized slag concrete be considered for incorporation into the design. The basis of our discussion was that the maximum $2.00 price differential between normal weight concrete and semi-lightweight concrete at 120-125 lbs. per cu. ft. would be easily compensated for by savings in the structure. For example, the floor slabs themselves will be no more expensive, due to savings in the reinforcement requirements, and when additional savings in column size and column reinforcement, along with potential reduction in foundation concrete are considered, the use of semi-lightweight concrete in applicable areas should provide a substantial cost reduction. The designers were able to prove this to themselves and as a result semi-lightweight concrete with a unit weight no exceeding 125 lbs. per cu. ft. was specified for the floor slabs.

The basic argument in connection with weight is that the cost per pound of weight saved should be a minimum. Designers will often request prices on, say, 110 lb. per cu. ft. concrete and then when they find that it is going to cost them an extra $8.00 per yard to obtain it they discontinue their thoughts of using lightweight aggregate. With our pellets we are able to obtain 115 lb. concrete if required, but in order to do so we would have to include some expanded slag fine aggregate, plus a considerably higher quantity of cement. The price differential would therefore, jump to possibly, say, $5.00. In other words, the extra cost of producing concrete with a weight 10 lbs. lighter than a standard 125 lbs. per cu. ft. would be $3.00 or, say, 30 cents per lb. of weight saved. If the 25 lbs (150-125) of weight saved cost $2.00, the cost per lb. is 8 cents. Thus, to go from 125 to 115, the cost per pound is 4 times (30 cents divided by 8 cents) as much, and to go from 115 to 110, the cost is further 60 cents per lb. of weight saved. We also advise the designers to use safe specifications; this avoids complications on responsibility which may occur if the concrete doesn't reach the required weight and strengths at 28 days because the specifications have been set too close to the line.

Referring back to Century Twenty-One, the designer set an air dry weight specification maximum of 125 lbs. per cu. ft., with a strength of 3500 psi. The mix suggested for use was as follows:

Table 1 Suggested Mix Design

Cement	532 lb.
Dry 3/8" pellets	845 lb. @ 53.5 lb. per cu. ft.
Dry natural sand	1650 lb. @ 100.8 lb. per cu. ft.
Total water	320 lb.
W.R. Admixture	Lignin type
Air entraining agent	Neutralized Vinsol Resin
Air	7.0% + 1-1/2%
Slump	3.5 ins.

The fact that the designer allowed a slightly higher weight than 122 lbs. per cu. ft., which we would normally obtain, permitted the ready-mix producer to request that the air content be lowered to 5% ±1½ and the slump to 2½ ±½". Permission to make these adjustments was granted. This in turn provided an extra margin of safety on strength and the possibility of reducing the cement factor if test results indicated that the concrete as supplied met the requirements by more than the normal margin.

At the time of writing this report, the building is eleven stories in height and all of the floors are semi-lightweight. The plastic weight of the concrete has ranged from 122.3 lbs. per cu. ft. to 124.0 lbs. per cu. ft. and the 28-day air dry weight from 120 to 122.9. Concrete compressive strengths at 28 days have averaged 4025 psi., with a maximum of 4480 psi. The workability and finish have been good and we are advised that there is less cracking in the floor slab than would be anticipated if the concrete had been of normal weight. Approximately 8,000 cubic yards will be required for the floors of this building, all of which is being placed by conventional crane and bucket procedures. Recent discussions with the building designers have indicated that they are very happy with the concrete received to date and no undue problems or hidden costs have occurred. The floor slab thickness is 7½", with 3/4" cover over the steel. Part of the reason for the 7½" thickness of slab is the rigidity requirement for earthquake design (Hamilton is in the Zone 2 area), with other factors being strict limitations on deflection and sufficient thickness to obviate the need for compressive steel.

While National Slag LTD has been involved in two or three other structural type jobs with pelletized expanded aggregate, the successful completion of this prestige building will provide a milestone from which we hope to forge ahead with continued confidence in our product and techniques.