# DYNAMIC RESPONSE OF A 17 STOREY WELLINGTON BUILDING

BY

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The Robert Jones House on Jervois Quay in Wellington, New Zealand, has seventeen floors, the lowest four comprising a podium block through which passes an integrally connected tower section. The total floor area is approximately 6,800m$^2$ and the construction is of insitu reinforced concrete with precast unitised floor systems including insitu topping specifically designed to allow the exterior beams to hinge. The main frame of the tower section is of unusual configuration, only four deep columns being provided to resist the lateral loading in each of two perpendicular axes on plan. These eight main external columns are intended to resist unilateral bending only and were proportioned to have sufficient strength to prevent the formation of column mechanisms under design earthquake loads. No major internal beams are provided in the floor slabs but these are reinforced diagonally in plan. A typical floor in the tower section has an area of 260m$^2$ and a separate free standing amenities and stairway tower block of 33m$^2$ area on each floor is hinged to the main tower block through the stairway linkage to allow independent horizontal movements to take place. The building is founded on piles driven some 10 m. through reclaimed silts and loose weathered greywacke to sound greywacke rock.

In attempting to predict, at the preliminary design stage, the likely seismic loads using the normal mode, response spectrum approach it appeared probable that the second or third normal mode could be of very great relative significance since, on the basis of shear wave velocities previously determined for similar soil materials, a ground period estimate of 0.48 sec. was made.

Subsequently more refined modal analyses were undertaken as part of the design process. Specific allowance was made for the soil flexibility when defining the system stiffness. An effective equivalent viscous damping of 15% critical was assessed for the soil but in order to correlate the soil effects with the overall 5% critical damping selected on the basis of the reinforced concrete superstructure, an appropriate adjustment was made to the equivalent elastic stiffness of the foundation when setting up the mathematical model of the building. On applying modal participation factors derived from the Skinner design spectrum large second and third mode responses were determined so that when the "square root of the sum of the squares" method of determining the total seismic response was applied, unacceptable design shears were calculated. The loss of the algebraic sense of the individual higher mode storey shears rendered the combined shear values of very dubious value, leading to unrealistic lateral load design shear envelopes.

Previous numerical integration based seismic response studies had indicated that in general the higher modes of vibration take longer to reach their peak of participation in earthquake generated displacement-time histories and consequently a technique was developed in which the storey shears are determined using modal participation factors which are modified to take account of the time required to excite the individual modes to maximum participation. The nett effect of applying this technique in the particular design considered was to increase the column design shears to a set of apparently much more realistic values than were determined by direct application of the "square root of the sum of the squares" approach.

The method was developed with particular reference to the somewhat unusual Robert Jones building, thereby determining acceptable seismic design loads for this structure.

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