BRIEF

INTENSITIES: A STRICTLY SUBJECTIVE VIEW

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Seismology didn't start with the invention of the seismograph. Among its earlier successes was the idea of felt intensity and, since neither magnitudes nor recorded ground accelerations have given us satisfactory measures of the destructive powers of an earthquake, intensity scales have lingered on, treated with suspicion, abused, and a prey to curious revisions by belated successors to Adolfo Cancani.

Back in 1904 Cancani had the notion that the grades of the infant Mercalli scale should correlate neatly with accelerations. They don't, of course, but among engineers the hope of squaring this particular circle has been an unconscionable long time a-dying. On becoming disillusioned, disappointed circle-squarers have turned to abuse, their commonest anathema being to repudiate the scale as "subjective". No engineer of the true faith can admit a concept thus excommunicated without mortal peril to his reputation for objectivity and responsibility.

P. J. Barosh, who has produced the handiest guide to intensity measurement to appear in recent years, indeed describes intensity as "a rather subjective measure of shaking, based upon real effects of shaking of things". If he means what he says (and the rest of his comments suggest that he doesn't) he is mistaken. In deciding whether an observation can correctly be described as "subjective", the fact that it is inexact or approximate is not relevant; the question is whether it depends in some essential way upon who makes it. Indeed, before we could use the word in its strictest sense we should need to affirm that the observer was completely uninfluenced by the external world and didn't believe there was one.

If, like the Japanese scale, the Mercalli scale had confined itself to damaging intensities, charges of subjectivism could hardly have arisen. If crockery has fallen from shelves, furniture has moved, chimneys tumbled, or house-foundations cracked, all observers are likely to agree that these happenings are real in an objective sense. Intensity estimates high enough to interest the engineer are based upon similarly objective data. No reliable estimate is based upon a single indicator, and any two seismologists faced with the same set of data will, barring mistakes or misconceptions, arrive at the same result or, if the data are deficient, at similar estimates of uncertainty. The engineer's misgivings may apply more plausibly to the lower intensities, yet even such an observation as "felt only by a few persons at rest" is capable of independent verification. Voigt and Byerly showed as much more than a quarter of a century ago. The data are objective, the scale is objective, and the treatment is objective. If we must qualify intensities with an adjective, how about "non-instrumental"?

New Zealand intensity ratings have two important merits. They are based upon a version of the Mercalli scale that has been specifically devised for New Zealand conditions; and they are assigned by an experienced organisation that ensures that the data are correctly handled. Intensity values are still the best index to the behaviour of structures in general during a particular earthquake, and provide the readiest comparison of the damaging ground motions in different earthquakes or at different places in the same earthquake. There is no likelihood of our obtaining so detailed a picture by instrumental means. So, on behalf of felt intensities, could we have a little more respect?

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REFERENCES

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2. Eiby, G. A., 1965: The Assessment of Earthquake Felt Intensities. Proc. 3rd World Conf. on Eq. Engng. Paper III/E/10.
3. Eiby, G. A., 1966: The Modified Mercalli Scale of Earthquake Intensity and Its Use in New Zealand. N.Z. Jl. Geol. Geophys. 9: 122-9.
4. Voigt, D. S. and Byerly, P., 1949: The Intensity of Earthquakes as Rated from Questionnaires. Bull. Seismol. Soc. Amer. 39: 21-6.

For the convenience of readers, the Modified Mercalli Scale discussed in Ref. 3 is set out below. For detailed discussion refer to this reference.

MODIFIED MERCALLI SCALE (N.Z. Version, 1965)

MM 1 Not felt by humans, except in especially favourable circumstances, but birds and animals may be disturbed.
Reported mainly from the upper floors of buildings more than 10 storeys high.
Dizziness or nausea may be experienced.

Branches of trees, chandeliers, doors, and other suspended systems of long natural period may be seen to move slowly.
Water in ponds, lakes, reservoirs, etc., may be set into seiche oscillation.

MM 2 Felt by a few persons at rest indoors, especially by those on upper floors or otherwise favourably placed.

The long-period effects listed under MM1 may be more noticeable.

MM 3 Felt indoors, but not identified as an earthquake by everyone.
Vibration may be likened to the passing of light traffic.

It may be possible to estimate the duration, but not the direction.
Hanging objects may swing slightly.
Standing motorcars may rock slightly.

MM 4 Generally noticed indoors, but not outside.
Very light sleepers may be wakened.
Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building.

Walls and frame of buildings are heard to creak.
Doors and windows rattle.
Glassware and crockery rattles.
Liquids in open vessels may be slightly disturbed.
Standing motorcars may rock, and the shock can be felt by their occupants.

MM 5 Generally felt outside, and by almost everyone indoors.
Most sleepers awakened.
A few people frightened.

Direction of motion can be estimated.
Small unstable objects are displaced or upset.
Some glassware and crockery may be broken.
Some windows cracked.
A few earthenware toilet fixtures cracked.
Hanging pictures move.
Doors and shutters may swing.
Pendulum clocks stop, start, or change rate.

MM 6 Felt by all.
People and animals alarmed.
Many run outside.
Difficulty experienced in walking steadily.

Slight damage to Masonry D.
Some plaster cracks or falls.
Isolated cases of chimney damage.

Windows, glassware, and crockery broken.
Objects fall from shelves, and pictures from walls.
Heavy furniture moved. Unstable furniture overturned.

Small church and school bells ring.
Trees and bushes shake, or are heard to rustle.
Loose material may be dislodged from existing slips, talus slopes, or shingle slides.

MM 7 General alarm.
Difficulty experienced in standing.
Noticed by drivers of motorcars.
Trees and bushes strongly shaken.
Large bells ring.

Masonry D cracked and damaged.
A few instances of damage to Masonry C.
Loose brickwork and tiles dislodged.
Unbraced parapets and architectural ornaments may fall.
Stone walls cracked.
Weak chimneys broken, usually at the roof-line.
Domestic water tanks burst.
Concrete irrigation ditches damaged.

Waves seen on ponds and lakes.
Water made turbid by stirred-up mud.
Small slips, and caving-in of sand and gravel banks.

MM 8 Alarm may approach panic.
Steering of motorcars affected.

Masonry C damaged, with partial collapse.
Masonry B damaged in some cases.
Masonry A undamaged.

Chimneys, factory stacks, monuments, towers, and elevated tanks twisted or brought down.
Panel walls thrown out of frame structures.
Some brick veneers damaged.
Decayed wooden piles broken.
Frame houses not secured to the foundation may move.

Cracks appear on steep slopes and in wet ground.
Landslips in roadside cuttings and unsupported excavations.
Some tree branches may be broken off.

Changes in the flow or temperature of springs and wells may occur.
Small earthquake fountains.

MM 9 General panic.

Masonry D destroyed.
Masonry C heavily damaged, sometimes collapsing completely.
Masonry B seriously damaged.
Frame structures racked and distorted.

Damage to foundations general.
Frame houses not secured to the foundations shifted off.
Brick veneers fall and expose frames.

Cracking of the ground conspicuous.
Minor damage to paths and roadways.
Sand and mud ejected in alluviated areas, with the formation of earthquake fountains and sand craters.
Underground pipes broken.
Serious damage to reservoirs.

MM 10 Most masonry structures destroyed, together with their foundations.
Some well built wooden buildings and bridges seriously damaged.
Dams, dykes, and embankments seriously damaged.
Railway lines slightly bent.
Cement and asphalt roads and pavements badly cracked or thrown into waves.

Large landslides on river banks and steep coasts.

Sand and mud on beaches and flat land moved horizontally.
Large and spectacular sand and mud fountains.

Water from rivers, lakes and canals thrown up on the banks.

MM 11 Wooden frame structures destroyed.
Great damage to railway lines.
Great damage to underground pipes.

MM 12 Damage virtually total. Practically all works of construction destroyed or greatly damaged.

Large rock masses displaced.
Lines of sight and level distorted.
Visible wave-motion of the ground surface reported.
Objects thrown upwards into the air.

Categories of Non-Wooden Construction

Masonry A. Structures designed to resist lateral forces of about 0.1 g, such as those satisfying the New Zealand Model Building Bylaw, 1955. Typical buildings of this kind are well reinforced by means of steel or ferro-concrete bands, or are wholly of ferro-concrete construction. All mortar is of good quality and the design and workmanship is good. Few buildings erected prior to 1935 can be regarded as in category A.

Masonry B. Reinforced buildings of good workmanship and with sound mortar, but not designed in detail to resist lateral forces.

Masonry C. Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces.

Masonry D. Buildings with low standards of workmanship, poor mortar, or constructed of weak materials like mud brick and rammed earth. Weak horizontally.

Windows

Window breakage depends greatly upon the nature of the frame and its orientation with respect to the earthquake source. Windows cracked at MM 5 are usually either large display windows, or windows tightly fitted to metal frames.

Chimneys

The "weak chimneys" listed under MM 7 are unreinforced domestic chimneys of brick, concrete block, or poured concrete.

Water Tanks

The "domestic water tanks" listed under MM 7 are of the cylindrical corrugated-iron type common in New Zealand rural areas. If these are only partly full, movement of the water may burst soldered and riveted seams.

Hot-water cylinders constrained only by supply and delivery pipes may move sufficiently to break the pipes at about the same intensity.