MODIFIED MERCALLI INTENSITY SCALE OF 1931

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The formation of a satisfactory earthquake intensity scale has long been a subject for consideration and discussion among those who are interested actively in studies of shock intensity and its geographic manifestation. The task is more difficult than may appear at first, not only because a large quantity of reliable data is a fundamental necessity, but because questions inevitably arise concerning the application of the scale in dealing with phenomena which may be regarded as special cases, or when taking account of special geologic conditions. Most serious, however, is the fact that we do not know exactly what factors combine to constitute intensity as it is ordinarily understood. We are not yet in position to correlate destructive effects with instrumental data so as to establish an adequate measure of intensity. Though the importance of the factor of acceleration is recognized, we have as yet no satisfactory definition of intensity, no formula expressing earthquake violence in terms of ground movement.

Many seismologists have long recognized that the Rossi-Forel scale, which has been in wide use for many years, has become inadequate for present-day needs. Effects in modern buildings, including tall structures, the behavior of motor cars and heavy trucks, effects on underground pipe systems, etc., are items now often included in reports upon shocks submitted by observers, and such data should have place in a modern intensity scale. The Rossi-Forel scale is very brief, it subdivides the intensity range unevenly and inadequately, and it does not afford clear distinctions between earthquake effects produced in poorly built and well-built structures. In many places it has already given way to other scales, without uniformity of usage.

The scale proposed here is a modification and condensation of the Mercalli-Cancani scale as formulated by Sieberg,[1] worked out at the Seismological Laboratory in Pasadena, California. Only slight changes were made fundamentally. Provisional drafts of the revised form were submitted for criticism and comment to the United States Coast and Geodetic Survey at Washington, D.C., to the Central Station of the Jesuit

[1] A. Sieberg, "Erdbebenkunde," pp. 102–104, Jena, 1923.

Seismological Association at Saint Louis, Missouri, to Professor Perry Byerly at the University of California at Berkeley, and to several others. Only minor further changes and additions were suggested, including, however, omission of the acceleration limits for the grades of the scale proposed originally by Cancani, and re-arrangement of the items which define the several grades so as to group together items referring to phenomena of the same general kind. An abridged version of the scale was also suggested, a form adapted for the use of those who desire simply an outline of the principal features.

The scales here proposed are intended for the use of experienced students only. This idea was foremost in the original revision worked out at Pasadena, and the provisional draft was prefaced by the following note:

> To evaluate intensity critically account must be taken of duration of shaking; nature of ground underneath locality and whether surface is level, gently sloping or steep; whether observers were outdoors, or indoors, in what kind of structure, on what floor, whether quiet or active, and if active how occupied; also whether the motion is rapid or slow, simple or complex, and whether it begins gradually or abruptly. This requires experience. Because of the entry of these factors in different degrees no intensity scale of this kind is suitable for general use, even though correct estimates might often be made.

While often it is not possible to take adequate account of all these factors, nevertheless it is desirable to obtain reports upon the phenomena experienced, rather than estimates made by the observers in terms of one or the other of these scales. Publication of the scales is desirable, however, since they point out effects commonly observed and will serve to guide observers in noting items which it is important to report. Unusual effects, however, should also be reported. Such observations may be of the highest importance.

The scale here presented is now in use at Pasadena, and it has the endorsement of other organizations and individuals in the United States active in seismological work. The United States Coast and Geodetic Survey will use it in the publication of its seismological results for 1931.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

Adapted from Sieberg's Mercalli-Cancani scale, modified and condensed.

I **Not felt** — or, except rarely under especially favorable circumstances.
Under certain conditions, at and outside the boundary of the area in which a great shock is felt:

[I, R.F.] sometimes birds, animals, reported uneasy or disturbed;
sometimes dizziness or nausea experienced;

sometimes trees, structures, liquids, bodies of water, may sway—doors may swing, very slowly.

II **Felt indoors by few, especially on upper floors,** or by sensitive, or nervous persons.

Also, as in grade I, but often more noticeably:

[I to II R.F.]

sometimes **hanging objects may swing,** especially when delicately suspended;

sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly;

sometimes birds, animals, reported uneasy or disturbed;

sometimes dizziness or nausea experienced.

III **Felt indoors by several, motion usually rapid vibration.**

Sometimes not recognized to be an earthquake at first.

Duration estimated in some cases.

[III R.F.]

Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away.

Hanging objects may swing slightly.

Movements may be appreciable on upper levels of tall structures.

Rocked standing motor cars slightly.

IV **Felt indoors by many, outdoors by few.**

Awakened few, especially light sleepers.

Frightened no one, unless apprehensive from previous experience.

Vibration like that due to passing of heavy, or heavily loaded trucks.

[IV to V R.F.]

Sensation like heavy body striking building, or falling of heavy objects inside.

Rattling of dishes, windows, doors; glassware and crockery clink and clash.

Creaking of walls, frame, especially in the upper range of this grade.

Hanging objects swung, in numerous instances.

Disturbed liquids in open vessels **slightly.**

Rocked standing motor cars noticeably.

V **Felt indoors by practically all, outdoors by many or most: outdoors direction estimated.**

Awakened many, or most.

Frightened few—slight excitement, a few ran outdoors.

Buildings trembled throughout.

Broke dishes, glassware, to some extent.

[V to VI R.F.]

Cracked windows—in some cases, but not generally.

Overturned vases, small or unstable objects, in many instances, with occasional fall.

Hanging objects, doors, swing generally or considerably.

Knocked pictures against walls, or swung them out of place.

Opened, or closed, doors, shutters, abruptly.

Pendulum clocks stopped, started, or ran fast, or slow.

Moved small objects, furnishings, the latter to slight extent.

Spilled liquids in small amounts from well-filled open containers.

Trees, bushes, shaken slightly.

VI **Felt by all,** indoors and outdoors.
Frightened many, excitement general, some alarm, many ran outdoors.
Awakened all.

[VI to VII R.F.]
Persons made to move unsteadily.
Trees, bushes, shaken slightly to moderately.
Liquid set in strong motion.
Small bells rang—church, chapel, school, etc.
Damage slight in poorly built buildings.
Fall of plaster in small amount.
Cracked plaster somewhat, especially fine cracks **chimneys** in some instances.
Broke dishes, glassware, in considerable quantity, also some windows.
Fall of knick-knacks, books, pictures.
Overturned furniture in many instances.
Moved furnishings of moderately heavy kind.

VII **Frightened all**—general alarm, all ran outdoors.
Some, or many, found it difficult to stand.
Noticed by persons driving motor cars.
Trees and bushes shaken moderately to strongly.
Waves on ponds, lakes, and running water.
Water turbid from mud stirred up.
Incaving to some extent of sand or gravel stream banks.
Rang large church bells, etc.
Suspended objects made to quiver.

[VIII— R.F.]
Damage negligible in buildings of good design and construction, **slight** to moderate in well-built ordinary buildings, **considerable** in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc.
Cracked chimneys to considerable extent, **walls** to some extent.
Fall of plaster in considerable to large amount, also some stucco.
Broke numerous windows, furniture to some extent.
Shook down loosened brickwork and tiles.
Broke weak chimneys at the roof-line (sometimes damaging roofs).
Fall of cornices from towers and high buildings.
Dislodged bricks and stones.
Overturned heavy furniture, with damage from breaking.
Damage considerable to concrete irrigation ditches.

VIII **Fright general**—alarm approaches panic.
Disturbed persons driving motor cars.
Trees shaken strongly—branches, trunks, broken off, especially palm trees.
Ejected sand and mud in small amounts.
Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters.
Damage slight in structures (brick) built especially to withstand earthquakes.

[VIII+ to IX— R.F.]
Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling.

Fall of walls.
Cracked, broke, solid stone walls seriously.
Wet ground to some extent, also ground on steep slopes.
Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers.
Moved conspicuously, overturned, very heavy furniture.

IX Panic general.
Cracked ground conspicuously.
Damage considerable in (masonry) structures built especially to withstand earthquakes:
[IX+ R.F.] threw out of plumb some wood-frame houses built especially to withstand earthquakes;
great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames; serious to reservoirs; underground pipes sometimes broken.

X **Cracked ground,** especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks.
Landslides considerable from river banks and steep coasts.
Shifted sand and mud horizontally on beaches and flat land.
[X R.F.] Changed level of water in wells.
Threw water on banks of canals, lakes, rivers, etc.
Damage serious to dams, dikes, embankments.
Severe to well-built wooden structures and bridges, some destroyed.
Developed dangerous cracks in excellent brick walls.
Destroyed most masonry and frame structures, also their foundations.
Bent railroad rails slightly.
Tore apart, or crushed endwise, pipe lines buried in earth.
Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI Disturbances in ground many and widespread, varying with ground material.
Broad fissures, earth slumps, and land slips in soft, wet ground.
Ejected water in large amount charged with sand and mud.
Caused sea-waves ("tidal" waves) of significant magnitude.
Damage severe to wood-frame structures, especially near shock centers.
Great to dams, dikes, embankments, often for long distances.
Few, if any (masonry), structures remained standing.
Destroyed large well-built bridges by the wrecking of supporting piers, or pillars.
Affected yielding wooden bridges less.
Bent railroad rails greatly, and thrust them endwise.
Put pipe lines buried in earth completely out of service.

XII **Damage total**—practically all works of construction damaged greatly or destroyed.
Disturbances in ground great and varied, numerous shearing cracks.

Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive.
Wrenched loose, tore off, large rock masses.
Fault slips in firm rock, with notable horizontal and vertical offset displacements.
Water channels, surface and underground, disturbed and modified greatly.
Dammed lakes, produced waterfalls, deflected rivers, etc.
Waves seen on ground surfaces (actually seen, probably, in some cases).
Distorted lines of sight and level.
Threw objects upward into the air.

MODIFIED MERCALLI INTENSITY SCALE OF 1931
(Abridged)

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage **negligible** in buildings of good design and construction; **slight** to moderate in well-built ordinary structures; **considerable** in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII. Damage **slight** in specially designed structures; **considerable** in ordinary substantial buildings with partial collapse; **great** in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars.

IX. Damage **considerable** in specially designed structures; well designed frame structures thrown out of plumb; **great** in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

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Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects. The Modified Mercalli intensity scale (MM or MMI), descended from Giuseppe Mercalli's Mercalli intensity scale of 1902, is a seismic intensity scale used for measuring the intensity of shaking produced by an earthquake. It measures the effects of an earthquake at a given location, distinguished from the earthquake's inherent force or strength as measured by seismic magnitude scales (such as the "Mw" magnitude usually reported for an earthquake).Â When Harry O. Wood and Frank Neumann translated this into English in 1931 (along with modification and condensation of the descriptions, and removal of the acceleration criteria), they called it the "Modified Mercalli Intensity Scale of 1931".[9] (MM31. The Mercalli intensity scale is another seismic scale. It labels an earthquake from I to XII depending on the effects of the earthquake. Earthquakes are one of the most dangerous disasters that humans have to face. However, most earthquakes are actually not even noticeable. There are in fact millions of earthquakes that occur in a year. Of those, only 1.3 million are even noticeable by humans, at least according to the U.S. Geological Survey. Most of these actually occur in remote areas far from people and are often so low in intensity that most people would not notice. There are many reasons