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European Macroseismic Scale 1992
(up-dated MSK-scale)

Editor
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(up-dated MSK-scale)

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Preface

It is an honour and particular pleasure for me to introduce this monograph devoted to the new "European Macroseismic Scale 1992", which was completed at the XXIII. General Assembly of the European Seismological Commission in Prague 1992.

It is legitimate to mention here that the ESC always paid great attention to the intensity classification of earthquakes. In 1964 the MSK-64 scale, named after its fathers V. Medvedev, W. Sponheuer and V. Karnik, was recommended by the ESC and widely used for almost thirty years in its basic form. However, a modified version of this scale was introduced in 1981.

Now, after more than five years of intensive work, we have in our hands an improved European Macroseismic Scale that embodies all the former achievements along this line. It is recommended by the ESC-General Assembly 1992 for general use within a three-year test-period. This seems to be a useful and correct procedure in introducing an international standard by the ESC.

It is noteworthy that mainly the use of computer-based methods in the evaluation of macroseismic data finally lead to a better definition of the scale. It has to be understood that the intensity scale can only be improved by continuous discussion and using it in practice, but new ideas should not change the basic principles of the scale. The new scale presented here is a good example how to realise this difficult task.

Let me express my appreciation to the members of the ESC working group "Macroseismic Scales" and to all other colleagues who contributed to the present version. It is an excellent result of one of those long-term international projects, which are supported in first line by the ESC. I want to express my special thanks to the editor and WG-Chairman Dr. G. Grünthal, Potsdam, and to the other editors Dr. R. M. W. Musson, Edinburgh, Dr. J. Schwarz, Weimar, and Dr. M. Stucchi, Milan, for their tremendous efforts.

The ESC recognises the support of the Council of Europe through the Centre Européen de Géodynamique et de Séismologie in Luxembourg, the Swiss Reinsurance Co. in Zurich and the Bavarian Insurance Co. in Munich for hosting workshops. Our thanks are directed also the board of the "Cahiers" for the edition of this volume.

Prague, March 8, 1993
Ludvik Waniek
President of the ESC

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1 INTRODUCTION

The purpose of this issue of the Cahier du Centre Europèen de Gèodynamique is to present the new, state-of-the-art, up-dating of the MSK intensity scale by the Working Group on Macroseismic Scales. This Working Group of the European Seismological Commission was reactivated during the XXI. ESC - General Assembly in Sofia in September 1988.
A Call for Proposals for the Up-Dating of the MSK Intensity Scale, together with some general thoughts, which ought to be taken as a basis for up-dating, were distributed as an annexe to the 3rd ESC Bulletin in March 1989. The responses to this appeal for proposals were compiled and distributed in early 1990. Four WG meetings were held: June 7-8, 1990 in Zürich, May 14-16, 1991 in Munich, and March 16-18, 1992 in Walferdange/Luxembourg as well as one with less participants, from June 17-21, 1992 in Potsdam.

It is worthwhile to give briefly some information on the establishment of the original version of the MSK intensity scale by S. V. Medvedev/Moscow, W. Sponheuer/Jena, and V. Kárník/Prague. The introduction of an up-dated scale was initiated by the Institute of Physics of the Earth in Moscow in the early sixties by requesting proposals for improving and completing the scale introduced by Medvedev in 1953 and used in the Soviet Union as the GEOFIAN-scale. In response to this Kárník initiated in 1961 the cooperation of the three fathers of the MSK-scale. A first draft of a new scale, based on the Mercalli-Cancani-Sieberg scale (MCS), the Modified-Mercalli scale (MM), and the Medvedev-scale, was compiled by Sponheuer and Kárník in spring 1962 in Prague. It was revised by Medvedev and Sponheuer in July 1962 and presented as the first draft of the new scale during the 7th Assembly of the ESC in September 1962 in Jena. It was intended at that time to create a unique world-wide scale by combining the experience gathered at that time from the application of the MCS-, the MM-, and the GEOFIAN-scale. The 1962 version of the scale was circulated to all major seismological institutions at that time; not only in Europe but also in Japan, North- and South-America etc. The extensive responses, e.g., from New Zealand, Japan, Spain, Greece, were incorporated by Sponheuer and Medvedev into the second draft in spring 1963 in Moscow. It was presented by Kárník as the “modified scale MSK” during the General Assembly of the IUGG 1963 in Berkeley. According to a recommendation of the UNESCO Working Group on Seismic and Seismotectonic Maps, from December 1963, the process of establishing the new scale as an international standard one should be speeded up in order to present the new scale to the UNESCO Intergovernmental Meeting on Seismology

and Earthquake Engineering in Paris in April 1964. Therefore, Sponheuer and Medvedev drafted the third version of the new scale, which was presented as the scale MSK 1964 during the above-mentioned meeting in Paris. In the same year it was introduced during the ESC meeting in Budapest. This version of the scale is the one known today as the MSK-64 scale.
Slight, barely noticeably changes to the MSK-64 were proposed by Medvedev in 1976 and 1978. At that time, it became evident by many users that the scale needed several improvements, more clarity and adjusting to newly introduced construction techniques. An analysis of the problems arising with the application of the MSK-64 scale was made by an Ad-Hoc Panel of Experts during a meeting in Jena in March 1980. But the recommendations for changes of the scale from this group of experts were also generally of a minor nature.

Other serious attempts for more drastic changes of the scale, or even for its replacement by a completely different version, were made by J. A. Ershov and N. V. Shebalin in 1984 and by J. Drimmel in 1985. Their sophisticated procedures were suitable mainly for special analysis of particular cases, but less suitable for rapid routine intensity evaluations. Such substantial changes to the scale involve the danger of changing the internal consistency of the scale. This may result in intensity evaluations which could be different from earlier applications of the MSK-scale and which would require a reclassification of all earlier intensity assessments. This should be avoided at all costs. It would result in a complete confusion in all studies on seismicity and seismic hazard which draw heavily on macroseismic data. Precisely this problem was explicitly mentioned in the Call for Proposals for Up-Dating from March 1989. It was further emphasised that any changes to the scale should be made carefully so as not to change its internal consistency.

Other general aspects considered to be fundamental to the up-dating were as follows:
- the robustness of the scale, i.e., minor differences in diagnostics should not make large differences in the assessed intensity;
- the simplicity of the scale's use;
- the insight that the scale should be understood and used as a compromise solution, because no intensity scale can hope to encompass all the disagreements between diagnostics for defined intensities - such disagreements may also reflect differences in cultural conditions in the regions where the scale is used;
- the rejection of any intensity corrections for soil conditions or geomorphological effects, because detailed macroseismic observations should just be a tool for finding

and elaborating such amplification effects;
- the understanding of intensity values as being representative for any village, a small town or a part of a larger town instead of point intensities (for one house etc.).

The specific problems to be solved by the WG on Macroseismic Scales - on the basis of the above-mentioned aspects - were:
- the need to include mention of new types of buildings, especially those including antiseismic design features, which are not covered by existing versions of the scale;
- the need to address a perceived problem of non-linearity in the scale arrangement at the junction of the degrees VI and VII (which, after thorough discussion, proved to be illusory);
- the need to improve generally the clarity of the wording in the scale;
- the need to decide what allowance should be made for including high-rise buildings for intensity evaluations;
- whether guidelines for equating intensities to physical parameters of strong ground motions, including their spectral representations, should be included;
- to design a scale that not only meets the needs of seismologists alone, but which also meets the needs of civil engineers;
- to design a scale which should be also suitable for the evaluation of historical earthquakes;
- the need for a critical revision of the usage of macroseismic effects visible in the ground (like rock falls, fissures in ground) and the exposure of underground structures to shakings.

The members of the WG are aware that the twelve-degree macroseismic scales are in fact ten-degree scales; i.e., intensity I means no observation and the intensities XI and XII are, quite apart from their very limited practical importance, difficult to distinguish. If one takes into account the very rare practical use of the intensities II and XI as well as the fact that intensity XII defines maximum effects, which are not to be expected to occur in reality, the result is even an eight-degree scale. But, as mentioned above, to avoid any confusion, the classical numbering is adhered to.

The basis for elaborating the up-dated scale version was the so-called MSK-81 scale; a version in which the recommendations by the Ad-Hoc Panel of Experts from 1980 (published in Gerlands Beitr. Geophys.,1981) and the earlier proposals by S. V. Medvedev were incorporated. This version was attached to the first Call for Proposals to activate the Working Group.

During the first WG meeting it was discussed, as an introduction, what the term "macroseismic intensity" actually means. After a long debate as to whether intensity is inherently a measure of ground motion or not, the following working definition was agreed: "The macroseismic intensity is a classification of the severity of ground shaking on the basis of observed effects in a limited area".

Another essential issue of the first meeting was the agreement on the structure of the new scale. It was decided that the new scale should be modular in design and that the scale should include a guideline on its usage. This guide should be illustrated by photographs depicting exactly what is meant by the different defined building types and grades of damage. The modular design means the creation of a so-called *Core Scale*, i.e., the definitions of the single intensity degrees, similar in content to the classical scale version but without all weaker and less essential diagnostics, and also a number of modules addressing particular problems to avoid the possibility of the modules being used separately.

An *Annexe A on Intensity Evaluation of Historical Earthquakes* should deal with the restrictions that need to be borne in mind when evaluating intensities of historical earthquakes. It was intended that it should include also a reduced version of the scale suggested solely for application to historical information. An *Annexe B on Engineered Structures (Buildings)* should enable an extension of the scale to be applied to engineered and antiseismic constructions; i.e., it should consider a greater number of classes of buildings than all previous scales. It should especially meet the needs of engineers. An *Annexe C on Seismogeological Effects* should deal in greater depth with phenomena like landslips, rock falls etc. These diagnostics have been deleted from that part which is now referred to as the Core Scale. It is known that effects of this type are often unreliable as exact intensity diagnostics - especially secondary, triggered effects may have little correspondence with intensity. But when used with caution they can be useful. Therefore, it seemed undesirable to delete them entirely from the scale.

It was agreed also to change the arrangement of the new scale (core part). The previous MSK versions were arranged as:

a) Effects on persons and surroundings
b) Effects on structures (damage)
c) Effects on nature.

The new arrangement is:

a) Effects on humans
b) Effects on objects and on nature (excluding damage to buildings, effects on ground and ground failure)
c) Damage to buildings.

Further written contributions to several aspects of the scale's updating were prepared for the second and the third WG meeting - not only by the participants of the meeting, but also by other workers, e.g., R. Glavcheva (Sofia). The proposals elaborated by the WG and available to the chairman up to spring 1991 were included into an actual working version of the scale prepared as a basis for the drafting of the Core Scale, which could generally be finished during the second WG meeting. Also, proposals for establishing the above-mentioned Annexes were thoroughly discussed. But serious problems connected with them became evident. Many details achieved during the WG meetings can be found in the extensive meeting notes taken by R. M. W. Musson.

The WG members met again during the ESC-General Assembly in September 1990 in Barcelona to draft a resolution for the "European Scale" adopted by the ESC-meeting. Activity reports commenting on the results achieved by the WG were presented in Barcelona as well as during the IUGG-General Assembly in Vienna 1991.

During the third meeting one main topic was the discussion of the first version of the Guide on How to Use the Scale prepared by R. M. W. Musson. The Guidelines are certainly an essential, straightforward step in improving the macroseismic practice. The participants recognized that it proved not to be useful, contrary to the intentions after the first meeting, to introduce an Annexe on Historical Earthquakes. This topic is dealt with in a paragraph of the Guideline and in the Annexe D.

Serious problems arose with the treatment of engineered or antiseismic constructions for intensity evaluation. Reasons for this are:

- the up to now limited knowledge and experience on the systematics of earthquake damage patterns for this category of buildings;
- the great variety of systems for classifying engineered constructions in seismic codes;
- disagreements between engineers and seismologists in the use of intensity and related research topics (e.g., a tendency among engineers to overestimate the importance of instrumental data in connection with intensities and therefore the danger to overcharge the concept of intensity);

- the often imprecise seismological approach to intensity assignment with regard to building types previously used in the MSK-scale; i.e. the general neglect of the quality of workmanship, the structural regularity, the strength of material, the state of repair etc., as well as the necessity to consider such features as scaling conditions.

Seismologists initially expected that a classification of engineered buildings could be devised that would allow their incorporation into the scale in a similar fashion to the original scheme. After long discussions it was accepted that engineered buildings can be used for intensity assignment only on the basis of earthquake resistant design principles. An essential step for overcoming these problems was the introduction of the vulnerability table which enables the possibility to deal in one scheme with different kinds of buildings and the variety of their actual ranges of vulnerability. In former versions of the MSK- scale the building types were defined in a rather strict way. This vulnerability table, as a compromise solution, covering different opinions and incorporating engineered and non-engineered buildings into a single frame was devised during the fourth meeting, at which G. Grünthal, R. M. W. Musson, J. Schwarz, and M. Stucchi participated. It has to be stressed that the adopted compromise, partly included in the Core Scale as well as given as Annexe B, can be understood mainly as an experimental or tentative solution of this problem, connected with the commitment to gathering more information and experiences on this subject, in order to become able to introduce necessary improvements.

Also, during the Potsdam meeting, the Guidelines were revised once more. The differentiation of buildings into vulnerability classes (part of the Core Scale) and a first version of a tabulated compilation of seismogeological and hydrological macroseismic effects were drafted. A few days later, J. Vogt and R. M. W. Musson, at Strasbourg, brought that table into a version which was the basis for the lay-out attached here as Annexe C. J. Schwarz compiled Annexe A, the set of photographs provided mainly by H. Tiedemann as well as by E. Kenjebaev and A. Taubaev.

In the course of the XXIII. ESC General Assembly, held in September 1992 in Prague, the outcome of the Working Group was made public first time in form of a poster as well as during a special session dedicated to the presentation of the up-dated MSK-scale. The numerous suggestions for further improvements, being mainly of a minor nature, submitted during or immediately after the Prague symposium, could be considered as a final phase of revision of the scale.

Because of the tentative and experimental nature of parts of the presented version of the up-dated MSK-scale, it has to be considered as a "working version" with the commitment to further revision after several years of practical experience. A period of three years has been stipulated for this, i.e., an improved version, especially regarding the use of engineered construction for intensity evaluation, can be expected for the XXV. ESC General Assembly. Some suggestions for future, not yet elaborated innovations and fields of further discussion are given in Annexe B. Users of the up-dated version of the scale are kindly requested to submit their comments for further improvements to the chairman of the Working Group "Macroseismic Scale", whose address is attached below.

The XXIII. ESC General Assembly 1992 in Prague adopted the above-described proposals of the WG and recommended: "use of the new 'European Macroseismic Scale 1992' (up-dated MSK-scale, MSK-92), proposed by the ESC-Working Group 'Macroseismic Scale' in parallel to the existing scales for a time period of three years, in order to collect experience under realistic conditions, especially on the more experimental parts of the scale on the vulnerability classes and engineered constructions. A final analysis should follow this test period before the scale will officially be recommended by the XXV. ESC General Assembly."

It would extend the scope of the introduction too much to deal with all the "ifs" and "buts" which arose unavoidably during the process of up-dating. It was necessary in each step of the work to find the right balance between the aimed consistency of the up-dated version with the original scale and several obviously excellent ideas for the scale improvement which were going beyond the goal defined for the WG activities. Some of these points are mentioned in the Guideline (e.g., the problem of the correlation of intensities with strong ground motion parameters), or are at least raised in annexes. Others will be subject of further activities. One of them will doubtless be the combination of the descriptive way of defining intensities with formalised procedures of data processing for providing possibilities to exclude (or at least to reduce) the subjective element in the intensity assessment. Several approaches to formalised procedures (or algorithms) for a computerised macroseismic intensity evaluation exist already. It has to be stressed that it was not an aim of the WG to create such algorithms - but to create the basis for them, i.e., to present updated, as clear as possible, qualitative descriptive definitions of what the different intensities should actually stand for. One of the next logical steps would be to establish, based on the defined intensities together with "rules" given in the Guidelines, a strictly defined formalised algorithm for performing as objective as possible intensity assessments. Such computerised methods can be only so good as the basic definitions on which they rely.

The new scale version with all its parts is a product of a cooperative team work - a team of seismologists and engineers. The chairman of the WG is grateful for all the efforts which the participants of the WG have applied to the elaboration of the new version of the scale. The colleagues who have actively contributed to this process of updating, and who were respectively participants in the first three WG meetings, are: G. Grünthal (Potsdam), V. Kárník (Prague), E. Kenjebaev (Alma-Ata), A. Levret (Fontenay-aux Roses), D. Mayer-Rosa (Zürich), R. M. W. Musson (Edinburgh), O. Novotny (Prague), D. Postpischl (Bologna), A. A. Roman (Kishinev), H. Sandi (Bucharest), V. Schenk (Prague), Z. Schenková (Prague), J. Schwarz (Weimar), V. I. Shumila (Kishinev), M. Stucchi (Milano), H. Tiedemann (Munich), J. Vogt (Strasbourg), J. Zahradník (Prague), T. Zsiros (Budapest).

Thanks are also due to the main authors or compilers of special parts of the results presented by the WG; these are R. M. W. Musson for drafting the Guide on How to Use the Scale as well as the Examples of Intensity Assignment (Annexe D), J. Vogt and R. M. W. Musson for drafting the Table on Seismogeological Effects, H. Tiedemann, J. Schwarz and E. Kenjebaev for introducing essential ideas on using engineered constructions in intensity assessments, for providing the basic information for the Annexe B on Engineered Construction, for providing and compiling the photographs of typical earthquake damages; M. Stucchi for co-ordinating the views and comments of seismologists and engineers in Italy and for finalizing the recommendations concerning the historical data, as well as additionally A. Taubaev (Alma Ata) for drafting the drawings illustrating different damage grades for different building types.
Especially acknowledged is the support of the WG activities by the Swiss Reinsurance Company, the Bavarian Reinsurance Company, and the Council of Europe.
Finally, the participants of the WG feel bound to remember to our late WG member Daniele Postpischl and the activities he contributed.

G. Grünthal
Chairman of the Working Group
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2 GUIDE TO THE USE OF THE INTENSITY SCALE

2.1 General Remarks

2.1.1 The nature of intensity

As stated in the introduction to this scale, intensity is here considered a classification of the severity of the ground shaking on the basis of observed effects in a limited area. Intensity scales, and the concept of intensity itself, have been evolving through the course of this century. From a pure hierarchical classification of effects, it has been tried, more and more, to develop a rough instrument for measuring the shaking; at least, it has been used in this sense.

It follows that an intensity scale is in some ways similar to a shorthand system, in that it allows the compression of a verbose description of earthquake effects into a single symbol (usually a number). To describe intensity in this way is useful in representing the limitations of the concept - intensity is descriptive in the manner of a prose account, rather than analytical in the manner of an instrumental measurement. Intensity is capable of analysis and interpretation, is indeed a very useful parameter, and its uses go beyond what could be done with a simple compilation of descriptions. But its basic nature needs to be kept in mind by the user so as not to overload the concept with expectations that it cannot meet.

The development of the scale can be seen most clearly in the consideration of damage and building types. At the purest level of classification, all damage of a particular type would be grouped together irrespective of the strength of the building damaged. At the other extreme, it would be necessary to know the exact strength of a building in order to estimate the amount of shaking required to produce a certain level of damage.

The up-dated version of the MSK scale incorporates a compromise, in which a fairly crude differentiation of the resistance of buildings to earthquake generated shaking (vulnerability) has been employed in order to give a simple and robust way of differentiating the way in which buildings may respond to earthquake shaking. This development is not yet completed; a further trend towards increased formalisation of the scale and of the procedures to be adopted in using it is likely, and desirable, in the future, but at present the amount of observational data that can be used for the construction of these formalised procedures is limited.

2.1.2 The usage of intensity scales

Traditionally the use of intensity scales has been chiefly through the media of the questionnaire survey and the field visit, applied immediately in the wake of an earthquake. With an increasing interest in past earthquakes since the mid-1970s, there has been a greater usage of intensity scales as tools to be applied to written materials of a very heterogeneous nature. Also, it is increasingly common for engineers and planners to turn to intensity as part of an approach to building predicative tools for estimating future earthquake losses.

This guideline will concentrate on a discussion of the general use of the scale. It should be stressed that, at present, all material in the scale and annexe dealing with anti-seismic engineered construction is experimental in status, since there is relatively little experience in assessing the effects of earthquakes on this type of building. References to engineered construction in the main body of the scale are printed in italics to emphasise this fact.

In the macroseismic study of an earthquake, the following simple stages can be discerned:

(i) Data acquisition - by questionnaire survey, field visit, appeals for information, literature search or other means.

(ii) Data sorting - organisation of the data into a form in which it can be interpreted by the user - this may be no more than arranging the questionnaires by place of origin.

(iii) Intensity assignment - the data are interpreted using the intensity scale and a table of places with intensities is produced.

This is usually then followed by mapping of intensities, which can be followed by contouring to produce isoseismal maps, from which various other analyses may be made. Isoseismal maps are often the basis for seismic zoning and zoning maps introduced into earthquake resistant design regulations (codes). In many European countries engineered structures are designed for seismic loads of a level which directly related an intensity value assigned to the seismic zone in which the building site lies. A discussion of these techniques is, however, beyond the scope of these guidelines. The following discussion concentrates on those matters that are closely related to the use of the intensity scale and the concept of intensity.

2.1.3 The structure and construction of intensity scales

The MSK intensity scale is one of a family of intensity scales which originated with a simple ten-degree scale by Mercalli, which was subsequently expanded by Cancani to twelve degrees, and then defined in a very full way by Sieberg as the Mercalli-Cancani-Sieberg (MCS) scale. It is this scale which forms the starting point not only for the MSK scale, but also for the numerous versions of the “Modified Mercalli” scale. All these twelve-degree scales have been shown to be roughly equivalent to one another in actual values. They vary in the degree of sophistication employed in the formulation.
In fact, although these scales have twelve degrees, in practice they tend to function as eight-degree scales. Intensity 1 means in practice “not felt”, and intensity 2 is so weak as to be usually not reported and so rarely used. At the other end of the scale, intensity 12 is defined in a manner such that it describes the maximum conceivable effects which can not necessarily be reached in an earthquake. Intensities 10 and 11 are hard to distinguish in practice, so intensity 11 is also rarely used. Thus the “working range” of all these scales tends usually to be from intensity 3 to intensity 10.
The major difference between the MSK scale and other intensity scales is in the detail with which different terms used are defined at the outset, in particular, building types, damage grades, and quantities, and these are now considered individually.

2.1.3.1 Building types and vulnerability classes

The use of letters to stand for various types of building originated with Richter’s 1956 version of the Modified Mercalli scale. This subdivision is not made out of architectural interest; it represents, very crudely, different levels of vulnerability. The same degree of shaking that will destroy an adobe hut will have much less effect on a well-constructed modern office block. It is clear, though, that the condition of a building also affects its vulnerability. To account for every last variation in vulnerability according to type and condition would make the scale far too unwieldy to be useful in practice, therefore, a compromise position is necessary.
Previous version of the MSK scale defined building classes solely by type of construction. In this version, it has been attempted to move closer to classes directly representing vulnerability. Accordingly, six classes of decreasing vulnerability are proposed (A-F) of which the first three represent the strength of a “typical” adobe house, brick building and reinforced concrete (RC) structure, i.e., they should be compatible with building classes A-C in the MSK-64 and MSK-81 scales. Classes D-F are intended to represent

approximately linear decreases in vulnerability as a result of improved level of anti-seismic design (ASD). Note that no correlation with specialised engineering vulnerability functions is intended in this draft, but this should be considered as an area of further development within the calibration of the scale. (In Annexe B an approach is presented which indicates how results of damage surveys can be transformed and incorporated in the scale.)

Since vulnerability is something which is very difficult to quantify in such a way as to be useful to the user of the scale, it is still necessary to define vulnerability in terms of building type. However, this is done graphically in Table 1 (section 3.1.1) taking into account the fact that vulnerability depends also on other factors such as state of disrepair, quality of construction, irregularity of building shape, etc. For each building type, Table 1 shows the most likely vulnerability class(es) for it, and also the probable range (shown as a dashed line where this is uncertain). To some extent, this table is experimental and may be refined in the final edition of the scale in a light of experience.

Vulnerability of modern engineered buildings, especially those incorporating antiseismic design features, is considered in more detail in Annexe B on Engineered Structures (Buildings). For the purpose of the scale the level of ASD is classified as low (minimal features), medium (improved) and high (meeting all qualifications). It has to be accepted that the level of ASD is mainly ruled by codes/earthquake resistant design regulations and, therefore, is dependent on the seismic zone coefficient of the site and the importance of buildings. It is possible also to classify the level of ASD on the basis of parameters which are directly related to the seismic zone given by national codes, i.e., on the basis of intensity or base shear.

Commonly the level of ASD should be relatively uniform within one place for which intensity has to be assigned. An investigator commencing a field study of earthquake damage should therefore begin by ascertaining what, if any, building code regulations are in force for the area in question, as this will help to determine the vulnerability level of engineered structures, which should be modified by taking into account the level of regularity, level of quality, serious defects of design and other factors contributing to damage (see Annexe B).

Engineered structures with modern structural systems, not designed against lateral seismic loads, can still provide a certain level of earthquake resistance which can be comparable to the level incorporated in engineered buildings with ASD. Also, structures designed against high levels of wind loading can be regarded as having inherent earthquake resistance. Well-built (non-engineered) wooden or masonry structures can behave in a fashion comparable to buildings with ASD typical for vulnerability classes D, E or F. In the case of these buildings the appropriate selection of vulnerability class should be made on the level of quality (strength of materials and workmanship) and the regularity. These factors, are, of course, equally important for buildings with ASD (see Annexe B).

2.1.3.2 Damage grades

The damage grades are also something of a compromise - grades 1-5 should ideally represent a linear increase in the strength of shaking. They do this only approximately, and are heavily influenced by the need to describe classes of damage which can be readily distinguished by the operator. A point which has not been made in previous versions of the scale is that different types of building respond and fail in different ways, and this has been addressed in the present draft by giving separate, illustrated accounts of damage to both masonry and reinforced concrete houses.

One should note the difference between structural and non-structural damage. When examining a damaged reinforced concrete building the level of damage to non-structural brick infills should be compared to the actual structural damage to the frame elements of the building.

2.1.3.3 Quantities

The use of quantitative terms (“few”, “many”, “most”) provides an important statistical element in the scale. It is necessary to confine this statistical element to broad terms, since any attempt to present the scale as a series of graphs showing exact percentages would be impossible to apply in practice and would destroy the robustness of the scale. But defining these terms numerically is not very easy. If few-many-most are defined as three contiguous ranges of percentages (e.g., 0-20%, 20-60%, 60-100%), the undesirable effect occurs that a small percentage increase in some observation may in one case cross a threshold value and put the intensity up by one degree, whereas in another case the same increase will not cross a threshold and so not have the same effect. Broadly overlapping definitions (0-35%, 15-65%, 50-100%) cause problems of ambiguity for an observed value (e.g., 25%) and widely separated definitions (0-20%, 40-60%, 80-100%) cause similar problems where a value may be undefined. A compromise solution has been found for this draft of the scale, using narrowly overlapping definitions, but no solution is ideal. The objective here has been to try and maximise the robustness of the scale, and the definitions of quantity presented here should be used with this in mind.

2.2 Assigning intensity

The descriptions under each degree of the intensity scale are idealised "word-pictures" of the effects to be expected at each level of intensity. Each effect described in the scale may be considered a diagnostic, or test, against which the data can be measured. This cannot be applied too rigorously, though. It is usually not practical to set up rigid formulae to apply to the data, since it is not to be expected that all diagnostics will be satisfied by the data in all cases.
While there is an element of subjectivity in assigning intensity, experienced investigators will rarely find significant disagreements with one another. It is impossible to establish guidelines to cover every eventuality, but the following may be helpful.
In addition, two examples of intensity assignment are presented in Annexe D, one from documentary data and one from questionnaire data. These examples are not intended to be models to be followed rigidly, but rather as illustrations of the processes of evaluation that can be used.

2.2.1 Intensity and place

Intensity is essentially place-related, and normally can only be considered with reference to a specified place, e.g., "the intensity at Pienza was 5" (or more correctly, "the intensity at Pienza was assessed as 5"). To say, "the intensity of the earthquake was 8", with no indication of place, is an improper usage. It should better be formulated as, "the maximum intensity of the earthquake was 8".
The question of how large or small a place may have an intensity assigned to it is important, and not easy to answer definitively. The problem arises because of the well-observed fact that shaking varies considerably, and rather capriciously, over small distances. Thus, in two adjacent houses, apparently identical in circumstance, it may be that an earthquake will be felt strongly in one, and not at all in the other, or that one will be severely damaged while the other sustains little or no damage.
The concept of intensity revolves around the idea that some level of severity of shaking is characteristic for a particular place, and this entails, firstly that the settlement is large enough for a statistically significant sample to be obtained, without being unduly affected by small-scale local peculiarities, and secondly, that it is not so large that genuine local variations are not blurred over.
Thus, intensity should not be assigned to a single building or street; neither should a single intensity be assigned to a metropolis or a county. In general circumstances, the

smallest place should be no smaller than a village, and the largest no larger than a moderately-sized European town. Thus, it is reasonable to assign a single intensity value to, say, Siena, but not to Milan. It would be better to divide Milan up into separate suburbs. No rigid rules will be stated, since individual circumstances will influence the user in the decisions he makes in particular cases.

It is also desirable to assign values to locations which are reasonably homogeneous, especially with regard to soil types, otherwise the range of shaking effects reported may be very large. In this respect, Siena is not such a good example. However, this is not always practicable, depending on the precision in the data and how they were gathered. In the case where a town has areas in which the geotechnical conditions are very different (for instance, one half might be on an alluvial bank but the other on a plateau) then different intensity values should be assessed for the two parts of the town independently.

2.2.2 Establishing the grade

In real life, the data available will often not match the intensity grade descriptions in every aspect. In such cases, the investigator must decide which degree provides the best fit to the data he has. In doing so, it is important to look for an element of coherence in the data overall, rather than to rely on any one diagnostic as a yardstick. It is necessary to be wary of giving too much weight to the occasional extreme observation, which might lead to an overestimation of the intensity at the place in question.

Where the data consist of questionnaires from individuals, or individual field observations, these data should be combined for each place to determine in how many instances a diagnostic was or was not observed.

Where the data consist of other descriptions, the effects may be reported in terms far from the wording of the intensity scale. In such cases, it may be useful to consider whether the overall tenor of the description compares with the general character of a degree of the intensity scale.

2.2.3 Use of negative information

Information that an effect definitely did not occur is often just as valuable as information that it did occur when determining intensity, and such data should not be neglected. However, to assume that an effect did not occur because it was not reported is dangerous and invalid unless there are specific reasons why such an assumption can be justified.

2.2.4 Reliability and data samples

A point which is important but often neglected, is that the macroseismic data available to the user is never, or very rarely, a complete record of the effects that occurred during an earthquake. When a town with 20,000 buildings in it is shaken by an earthquake, each one of those buildings will be affected in one way or another. The user may have data from only some few tens on which to base his assessment. In other words, his data are a sample from a complete population of observed effects. It is thus valid to ask: is this sample actually representative of the population as a whole or not?

The smaller the number of reports, in absolute numbers, the greater the error there is likely to be in the proportion of observers reporting a certain effect, compared to the true proportion that would be observed over the whole town. If the data have been gathered with proper attention to random sampling techniques, then it is possible to calculate statistically this error in the sample. Unfortunately, this is usually not the case. It is recommended that those who are involved with gathering and studying macroseismic information should make themselves acquainted with the questionnaire and sampling methodologies that have been developed in the social sciences.

The user may not be able to improve the reliability of his data, but he should at least have an idea of what the reliability is, and be able to communicate this; either by qualifying statements, inclusion of sample sizes, or by the use of typographical conventions such as using a smaller font to indicate intensities derived from weak samples.

The problem is likely to be less severe, and may hardly arise at all, in cases where the user has direct control of his data gathering by means of a field investigation. It may be very severe where the data are received second or third hand. A sweeping remark by a journalist about the severity of effects in a town may be based on very little investigation; the report of one observer may be rewritten as if it was typical when in fact it was not. This is often a particular problem with studies of historical earthquakes where the user is dependent on relatively few data which have chanced to survive.

An example may illustrate the point. Suppose the only information from a certain town is that many people found it hard to stand. This is a diagnostic for intensity 7, but without the support of any other diagnostics, is an assignment of intensity 7 justified? It is difficult to lay down precise guidelines as to what is, and what is not, sufficient evidence on which to base intensity assessment. A useful approach when the data are poor is to mark intensity assessment based on potentially unreliable data, using 7? or (7) or some similar form.

2.2.5 Reliability and uncertainty

It will often be the case that no single intensity degree can be decided upon with any confidence. In such cases, it is necessary to decide whether some approximate assessment of intensity can be made, or whether the data are so contradictory that it is better to leave the matter unresolved.

In cases where the data fulfil and exceed the descriptions for intensity 6, but clearly don't fulfil completely those for intensity 7, the best case is to treat the intensity as being the lower value. The descriptions given in the scale should be viewed as thresholds. If the effects of an earthquake at a particular place can be considered as passing the threshold for intensity 6, it may be considered that that intensity has been reached; if the threshold for intensity 7 is not passed, then the intensity may not be considered to be 7. It is recommended that the user preserves the integer character of the scale, and not uses forms such as "6.5" or "6½" or "6+". It is doubtful if any greater resolution of intensity is either necessary or realisable in practice. If it is felt to be essential for some reason to present more detail then it should be shown in a descriptive manner.

Example: in a village with 100 (masonry) houses, 15 of them, assessed as vulnerability class A, suffer damage of grade 1, 14 other A class houses suffer damage of grade 2; 19 houses, assessed as vulnerability B, suffer damage of grade 1, 9 other B class houses suffer damage grade 2. If damage alone is considered, there is more than enough to justify intensity 6, but not enough to justify intensity 7. The intensity is 6.

There may still be cases where the data can be interpreted equally well as (for example) 6 or 7 (but clearly not 8). In such cases the intensity should be written as 6-7, meaning either 6 or 7; it does not imply some intermediate value. Expressing intensity as a range of values is now quite common practice, especially for historical data which are frequently insufficient to permit better resolution. Wider ranges than spanning two degrees of the scale are possible; it would be possible to write 6-8, and this does *not* mean 7.

Example: a document says, "in our town chimneys fell down but no houses were seriously damaged". In this limited report there is no indication what was the percentage of chimneys that fell, so the intensity might be 6 or 7; the statement that there was definitely no serious damage indicates that the intensity was not 8. The intensity is 6-7.

Vague assignments, such as < 6 (less than 6) or > 7 (more than 7) are acceptable when no greater accuracy is possible.

Example: a document says, "there was a lot of damage at Cortona". If no other information can be obtained, the intensity is > 6.

A further problem is caused by ambiguity in the data; for example, effects on humans may only suggest intensity 6, while effects on structures suggest intensity 8, or vice versa. If this problem occurs consistently, it may indicate some significant regional or cultural factor is at work (people more easily alarmed; very poor local construction techniques) which should be taken into consideration. When applying the scale, when individual cases of this sort of problem occur, if no coherence can be discerned then it is necessary to express intensity as a range, as discussed above.

There will always be cases where the data are so devoid of detail, or so completely contradictory or incredible that no assignment can be made. In such cases, it is necessary to adopt some convention to indicate an observation, for example, a dot, or an F for "felt" and make no assignment. If necessary, an explanatory footnote can be attached.

Example: a chronicle states, "this earthquake was also at Ravenna, Ancona and Perugia". No intensity can be assigned to these three places, but it should be recorded that the earthquake was felt there with some appropriate symbol. Note that it is not even known whether there was damage or not on this limited information.

2.2.6 Notation

It used to be regarded as conventional that intensities be notated in Roman numerals, either to distinguish them more clearly from magnitudes or to stress the integer nature of the scale. Since Roman numerals are hard to handle by computer, this convention has to some extent lapsed. The use of Roman or Arabic numerals may now be considered a matter of taste.

There also exists a set of conventional symbols for plotting intensities, based on circles in which an increasing amount is filled in with higher intensity values. These symbols are in routine use in Eastern Europe, but not much elsewhere.

2.3 Assessing intensity from historical records

2.3.1 Historical and documentary data

The term "historical data" is frequently used to mean descriptions of earthquake effects from historical records, that is, written sources prior to the instrumental period (before 1900). It must be stressed, however, that important macroseismic data of the same kind are still available, and used, for earthquakes of the present century, and even for very recent events.

It is therefore practical to consider historical records and modern written evidence together as “documentary data”. This term is used here to differentiate descriptions of earthquake effects written for non-seismological purposes from questionnaire data gathered under the guidance of seismologists. These data need to be retrieved and interpreted according to historical methods, irrespective of whether they relate to the 1890s or 1980s.

Retrieving and handling documentary records requires care and expertise, as a large amount of recent literature shows. In particular, the investigator who processes documentary records must be aware that the information has often arrived at him after a long and complicated itinerary. It is of great importance, therefore, to start by considering the context of the data in both historical, geographical and literary terms.

Particular attention should be paid to the following points:

(i) The value of the source, considering the motivation for writing and the context in which it has been produced. What is the sensitivity of the source to earthquakes and other natural events? (For example, at lower intensities a personal diary is much more likely to record an earthquake than the minutes of a town council.)

(ii) The context in which the report appears may contain significant information, and should not be ignored. For instance, a book may contain a short description of earthquake effects in one chapter, but include details that correct this information in some respect elsewhere in the volume. If the earthquake report is extracted in isolation, this qualifying information, which may be vital, will be lost. The nature of the wording is also important, and information should not be precised in such a way as to remove the nuances of the original.

(iii) The spatio-temporal location of the information. This is very important: careless handling here can result in duplication of earthquakes, data on one earthquake being attributed to a different event, or to the right earthquake but in the wrong location. In some cases, data cannot be adequately resolved with regard to place or time or both - in such cases, this has to be clearly indicated when the data are mapped.

2.3.2 Building types (vulnerability classes) in historical records

Historical accounts often report in detail damage to special monumental buildings (castles, churches, palaces, towers, pillars, and so on). Less frequently do they report the effects on ordinary buildings, which are the only ones which can be used within the framework of the scale. The first kind of data will be discussed below in section 2.3.5,

as these buildings pose special problems.
With regard to ordinary buildings, the vulnerability classes of traditional houses range in most cases from A to B, even to C and D (wooden structures). Very little is known from the general literature about building typologies in Europe up to the 17th century, except for the obvious facts that people used the materials nearest to hand, and that the richer the owner, the better-built and better-maintained his house was likely to be. But in the Middle Ages, certainly, most houses in many parts of Europe were made of wood, and the transition to brick or stone was long, and sometimes only partial. Without detailed information, it is very difficult to make any reliable pronouncement on the strength of these structures; it is not certain, for instance, if medieval timber structures were as strong as those known today.
Some methods of resolving this problem can be suggested - for instance, if it is believed that the housing type at a particular place and date was either vulnerability class A or B, it is possible to assign intensity assuming A, make a second assignment assuming B, and then use the range of values given by the two assignments. Or it may be possible to consider other cultural factors; if there is evidence that structures were weaker in poor rural areas than in wealthier towns, it may be reasonable to assume vulnerability class A in hamlets and B in towns.

2.3.3 Total numbers of buildings

In order to assign intensity using the percentage of houses damaged, it is necessary to know not only how many houses were damaged, but also how many were not damaged. The sources of data that describe the damage do not systematically (or often) carry this sort of information also. However, information on the total number of buildings in a locality can often be obtained with some success by investigating other kinds of sources, such as demographic studies, topographical works, census data, and so on. In some cases, reliable figures can be found without difficulty. More frequently it is necessary to make use of extrapolations based on population data with various assumptions and correlations. These figures will carry some uncertainties which have to be taken into account when assessing intensity, often leading to uncertain - but still useful - estimates. An additional complication is that the figures available may relate to the territory surrounding a small town, including some villages, hamlets, and isolated houses, although the wording suggests that it is the town itself that is being described. The descriptions of damage can suffer from the same problem. Whether or not this problem can be resolved in individual circumstances, it is as well to recognise that such a situation can lead to misinterpretations of ±1 degree. In such cases it is probably better to stick to a range of intensities such as 7-8, etc.

2.3.4 Quality of descriptions

Documents reporting earthquake effects, depending on their nature, often concentrate on the most remarkable or newsworthy effects to the exclusion of all other details. The silence of a source with respect to minor effects can be due to a number of factors, and cannot be used as if it was proof that nothing happened other than what is described. Similarly, converse assumptions are also invalid; for instance, there is little sense in making such extrapolations as, "if the bell tower was thrown down, then at least some minor damage should have occurred to most of the other buildings". The only way to improve the data is by further investigation (and this may be simply unsuccessful). Information produced a few days, weeks, or even months after the earthquake, from the same or other sources, can be illuminating, either supplying new damage data or indirect evidence of the effects. For instance, evidence that life in a locality is going on much as usual after an earthquake - people are still living and working in their houses, the town council meets as usual, religious services continue - then this may be considered to be contradictory with a description of damage leading one to believe an intensity of 9.
If the data remain poor after all avenues have been exhausted then one must take it as it is and assess intensity with an uncertainty range that properly represents the poorness of the data. A good procedure is to keep a record of how decisions have been reached.

2.3.5 Damage to monumental buildings

Damage to monumental buildings is usually better represented in documentary sources than damage to ordinary houses, for two good reasons:
(i) These buildings are more important to the writers of such reports because of their social, economic, symbolical or cultural value.
(ii) The structural and non-structural complexity of such buildings is such that they may be more likely to be damaged than ordinary buildings, even though they may be better built. This is the case, for instance, when small architectural decorations are dislodged from churches during earthquake shaking which is generally below the level at which damage occurs. One should be careful not to overestimate intensity as a result of such effects.
Monumental buildings are usually unique, or only a few such buildings occur in one place. Therefore, it is impossible to use the data relating to them in a statistical way as the scale requires. Such data must therefore be handled with care, as complementary to other evidence (if available). If only data of this sort are available, intensity ranges

should be used to indicate the uncertainty in interpretation.
In some cases, where very detailed damage descriptions are given for a building which still stands and can be investigated, or for which there are detailed descriptions, useful conclusions can be drawn about the earthquake shaking by making a specialist analysis.

2.4 Restrictions in the use of intensity

2.4.1 Tall buildings and other special cases

In some cases, it may be inadvisable to attempt to use certain data for assigning intensities. A particular case in point relates to observations from high buildings. It is well-known that people in upper stories are likely to observe stronger earthquake vibration than those in lower stories. Various practices, such as reducing the assigned intensity by one degree for every so many floors, have been suggested, but never found general favour. Also, since very tall buildings may behave under earthquake loading in particular ways according to the frequency of the shaking and the design of the building, the increase of severity of shaking with elevation may be irregular. The recommended practice is to discount all reports from observers higher than the fifth floor when assigning intensity; although in practice the actual behaviour of individual buildings will vary considerably, especially dependent on the slenderness of the building. In general, the user should be more concerned with effects observed under normal circumstances rather than in exceptional cases.
As well as the height of buildings, their symmetry and regularity also influence the way they behave in an earthquake. This is particularly true with respect to damage, and affects all types of buildings, not just modern engineered constructions. The more regular and symmetrical the design, the better the building will withstand earthquake shaking. This is considered in more detail in the Annexe on Engineered Structures.
Observations from special structures, such as lighthouses, radio towers, etc, should not be used. Data from observers underground are also not easily comparable with observations made at the surface and should not be used.

2.4.2 Effects of soil conditions

However, in contrast, no attempt should be made to discard or reduce intensity assignments on the grounds that they were influenced by soil conditions. The increase in shaking due to soil amplification or topographical conditions is part of the hazard to which the built environment is exposed and should not be glossed over. If anomalously strong effects are reported in alluvial areas distant from other areas where strong effects are observed, the correct procedure is to assign high intensities as merited by the effects. It is then possible to interpret these high intensities as due to the soil amplification (although, of course, this may be only one among several contributory causes). Possible exceptions to this generalisation are discussed in the Annexe B on Engineered Structures.

2.4.3 Invalid inferences

A point which follows from the statistical nature of intensity is that no single effect is ever certain. This is important when attempting to infer a negative, rather than a positive conclusion. For example, the existence of a number of ancient slender spires in a particular region might be used to suggest that the overall exposure of the region to past earthquakes was fairly low, but it would be unwise to conclude from a single spire that such-and-such an intensity value had never been exceeded in the locality during the lifetime of the spire.

2.4.4 Observed and extrapolated intensities

Intensity as described in these guidelines refers entirely to a parameter derived from observational data. It is necessary to mention that on occasion intensity values will be encountered which have not been produced from observations at a place, but are extrapolations or interpolations of data from other places. This is most commonly seen in catalogues where compilers have extrapolated from observed values to calculate a presumed intensity exactly at the epicentre of the earthquake.
A discussion of such practices is beyond the scope of these guidelines, but it would be helpful if all intensity values cited which are not derived directly from real observations were distinguished clearly as such.

2.4.5 Correlations with ground motion parameters

Many attempts have been made to correlate intensity to specific physical parameters of ground motion, especially peak ground acceleration, and some early scales actually included equivalent peak ground acceleration values as part of the scale. While it is undeniable that the effects observed from which intensity values are deduced are a product of real ground motion parameters, the relationship between them is complex and not amenable to simple correlations; there is also evidence that peak ground acceleration is not the most important single parameter affecting intensity. Correlations between intensity and peak ground acceleration typically show very large scattering, so large as to make the predicted values of limited meaning.

For this reason, no attempt to include a comparative table of intensity and ground motion parameters, such as acceleration, has been made.

2.5 Effects on natural surroundings

Previous versions of the MSK intensity scale, and a number of other intensity scales, include reference to a number of effects on nature which have not been included in this version. It is considered that the evidence is insufficient to establish good correlation between these effects and particular intensity grades. Some general considerations on the limited use which may be made of such effects as well water changes, cracks in ground, landslides, or rockfalls are presented separately as Annexe C.

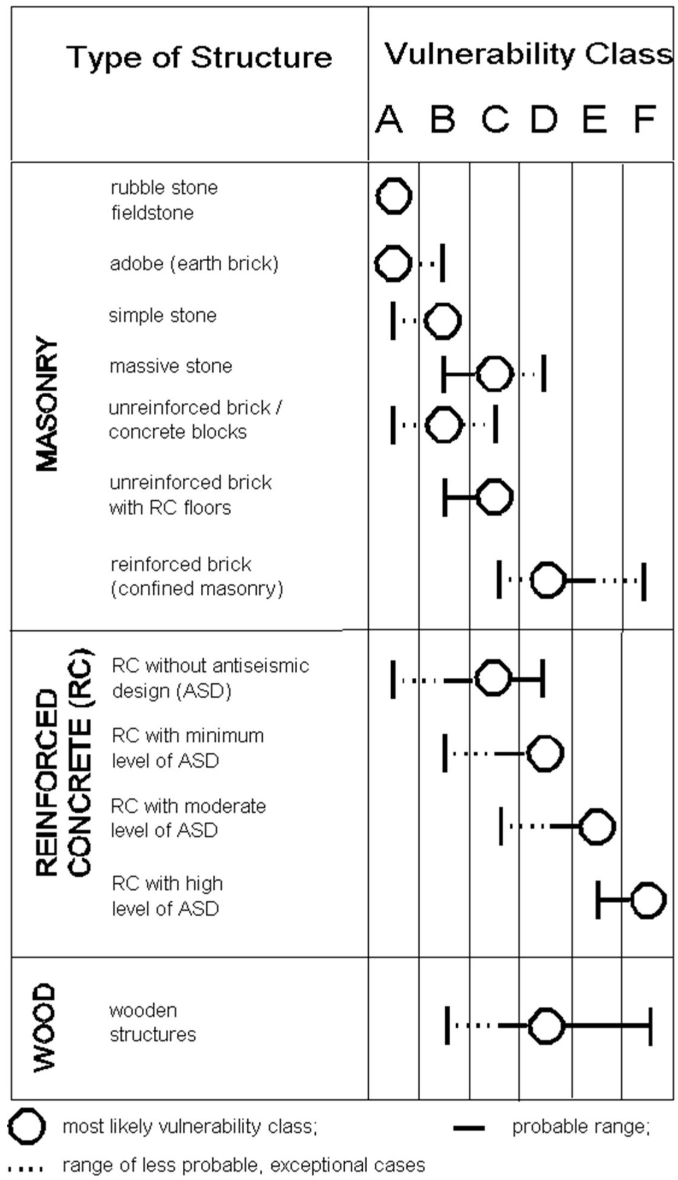
As a general rule, effects on nature should be used with caution and in conjunction with other effects. Data consisting exclusively of effects on nature normally should not be used for assigning intensities. Such data may be used to confirm intensities suggested by other diagnostics. This means that there is always a problem in estimating intensity in an unpopulated area; at best a range of intensities can be given. This is regrettable, but it is better to admit this restriction than to assign intensities which are too unreliable to be useful.

Care must be taken with the location of effects of this kind; they may occur in the countryside some considerable distance from the nearest town, to which they may be attributed by an imprecise report.

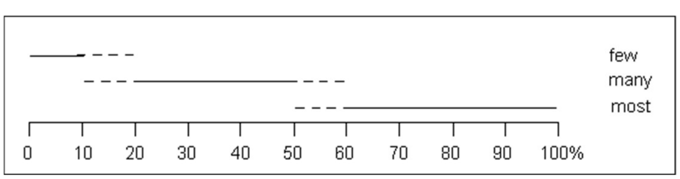
3 MACROSEISMIC INTENSITY SCALE

3.1 Classifications used in the European Macroseismic Scale

3.1.1 Differentiation of structures (buildings) into vulnerability classes



3.1.2 Definition of quantity



3.1.3 Classification of damage

Note: the way in which a building deforms under earthquake loading depends on the building type. As a broad categorization one can group together masonry buildings and buildings of reinforced concrete.

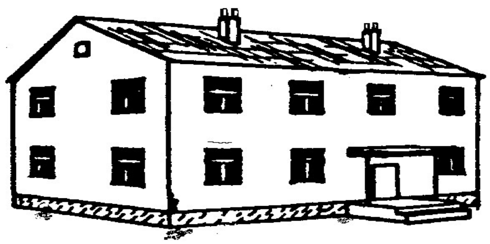
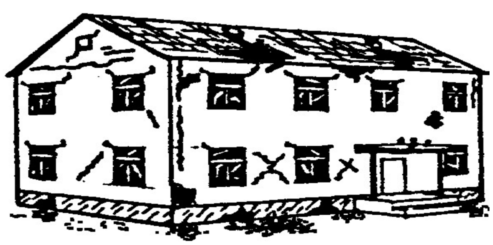
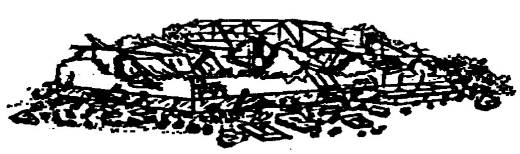
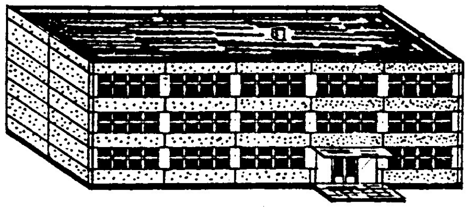
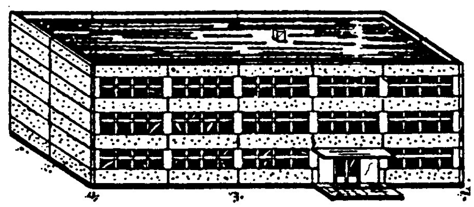
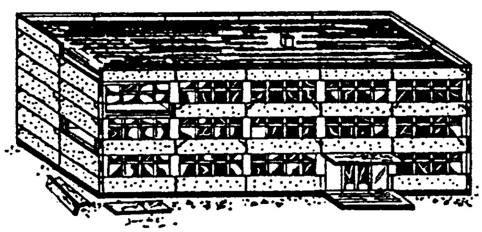
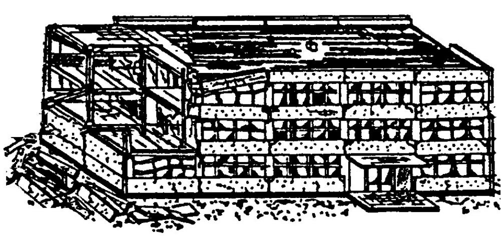
Table 2: Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage (no structural damage)** hair-line cracks in very few walls; fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases only.
	**Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)** cracks in many walls; fall of fairly large pieces of plaster; parts of chimneys fall down.
	**Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)** large and extensive cracks in most walls; pantiles or slates slip off. Chimneys are broken at the roof line; failure of individual non-structural elements.
	**Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage).** serious failure of walls; partial structural failure.
	**Grade 5: Destruction (very heavy structural damage)** total or near total collapse.

Table 3: Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage (no structural damage)** fine cracks in plaster over frame members and in partitions.
	**Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)** hair-line cracks in columns and beams; mortar falls from the joints of suspended wall panels; cracks in partition walls; fall of pieces of brittle cladding and plaster.
	**Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)** cracks in columns with detachment of pieces of concrete, cracks in beams.
	**Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage).** severe damage to the joints of the building skeleton with destruction of concrete and protusion of reinforcing rods; partial collapse; tilting of columns.
	**Grade 5: Destruction (very heavy structural damage)** total or near total collapse.

3.2 Definitions of intensity degrees

Arrangement of the scale:

a) Effects on humans
b) Effects on objects and on nature
   (excluding damage to buildings, effects on ground and ground failure)
c) Damage to buildings

Introductory remark:

The single intensity degrees can include the effects of shaking of the respective lower intensity degree(s), also when these effects are not mentioned explicitly.

I. Not felt

a) Not felt even under the most favourable circumstances.
b) No effect.
c) No damage.

II. Scarcely felt

a) The tremor is felt only by a very few (less than 1%) individuals at rest and in a special receptive position indoors.
b) No effect.
c) No damage.

III. Weak

a) The earthquake is felt indoors by a few. People at rest feel a swaying or light trembling.
b) Hanging objects swing slightly.
c) No damage.

IV. Largely observed

a) The earthquake is felt indoors by many and felt outdoors only by very few. A few people are awakened. The level of vibration is not frightening. The vibration is moderate. Observers feel a slight trembling or swaying of the building, room or bed, chair etc.
b) China, glasses, windows and doors rattle. Hanging objects swing. Light furniture shakes visibly in a few cases. Woodwork creaks in a few cases.
c) No damage.

V. Strong

a) The earthquake is felt indoors by most, outdoors by few. A few people are frightened and run outdoors. Many sleeping people awake. Observers feel a strong shaking or rocking of the whole building, room or furniture.
b) Hanging objects swing considerably. China and glasses clatter together. Small, top-heavy and/or precariously supported objects may be shifted or fall down. Doors and windows swing open or shut. In a few cases window panes break. Liquids oscillate and may spill from well-filled containers. Animals indoors may become uneasy.
c) Damage of grade 1 to a few buildings.

VI. Slightly damaging

a) Felt by most indoors and by many outdoors. A few persons lose their balance. Many people are frightened and run outdoors.
b) Small objects of ordinary stability may fall and furniture may be shifted. In few instances dishes and glassware may break. Farm animals (even outdoors) may be frightened.
c) Damage of grade 1 is sustained by many buildings; a few suffer damage of grade 2.

VII. Damaging

a) Most people are frightened and try to run outdoors. Many find it difficult to stand, especially on upper floors.
b) Furniture is shifted and top-heavy furniture may be overturned. Objects fall from shelves in large numbers. Water splashes from containers, tanks and pools.
c) Many buildings of vulnerability class B and a few of class C suffer damage of grade 2. Many buildings of class A and a few of class B suffer damage of grade 3; a few buildings of class A suffer damage of grade 4. Damage is particularly noticeable in the upper parts of buildings.

VIII. Heavily damaging

a) Many people find it difficult to stand, even outdoors.
b) Furniture may be overturned. Objects like TV sets, typewriters etc. fall to the ground. Tombstones may occasionally be displaced, twisted or overturned. Waves may be seen on very soft ground.
c) Many buildings of vulnerability class C suffer damage of grade 2. Many buildings of class B and a few of class C suffer damage of grade 3. Many buildings of class

A and a few of class B suffer damage of grade 4; a few buildings of class A suffer damage of grade 5. *A few buildings of class D suffer damage of grade 2.*

IX. Destructive

a) General panic. People may be forcibly thrown to the ground.
b) Many monuments and columns fall or are twisted. Waves are seen on soft ground.
c) Many buildings of vulnerability class C suffer damage of grade 3. Many buildings of class B and a few of class C suffer damage of grade 4. Many buildings of class A and a few of class B suffer damage of grade 5.
Many buildings of class D suffer damage of grade 2; a few suffer grade 3. A few buildings of class E suffer damage of grade 2.

X. Very destructive

c) Many buildings of vulnerability class C suffer damage of grade 4. Many buildings of class B and a few of class C suffer damage of grade 5, as do most buildings of class A.
Many buildings of class D suffer damage of grade 3; a few suffer grade 4. Many buildings of class E suffer damage of grade 2; a few suffer grade 3. A few buildings of class F suffer damage of grade 2.

XI. Devastating

c) Most buildings of vulnerability class C suffer damage of grade 4. Most buildings of class B and many of class C suffer damage of grade 5.
Many buildings of class D suffer damage of grade 4; a few suffer grade 5. Many buildings of class E suffer damage of grade 3; a few suffer grade 4. Many buildings of class F suffer damage of grade 2, a few suffer grade 3.

XII. Completely devastating

c) Practically all structures above and below ground are destroyed.

ANNEXE A

EXAMPLES ILLUSTRATING CLASSIFICATIONS OF VULNERABILITY AND DAMAGE USED IN THE SCALE

The examples of earthquake damage to buildings are classified into the type of structures, their vulnerability classes, and the grade of damage they suffered. The respective vulnerability and damage classes are indicated by a full dot. In cases of unclear relation to a class, an open circle is used to indicate the other possible but less probable class.

It has to be emphasised that it is not intended to demonstrate that the vulnerability class or the grade of damage can be evaluated on the basis of one picture only. Many of the examples were taken from damage inspections. The attached comments to the examples were derived during such inspections and can generally not be recognised from the given examples.

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Saisan East Kazakhstan 1990**	1	2	3	4	5
●								○	●		
TYPE OF STRUCTURE						**Adobe masonry**					

Comment:

Damage of grade 2 to 3; large and extensive cracks in most walls suggest grade of damage 3.

Figure A - 1

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Moldava, Leovo Carpathia**	1	2	3	4	5
●									○	●	
TYPE OF STRUCTURE						**Adobe masonry**					

Comment:

Damage of grade 3 to 4; the loss of connection between external walls and the partial failure of the wall at bottom of the corner suggest damage of grade 4 (serious failure of walls).
The right part of the building seems to be without serious damage and is obviously of a better stage of repair. A final classification should consider the reasons for this difference.

Figure A - 2

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Kairakkoum Tadjikistan 1985**	1	2	3	4	5
●										●	
TYPE OF STRUCTURE						**Adobe masonry (light roof)**					

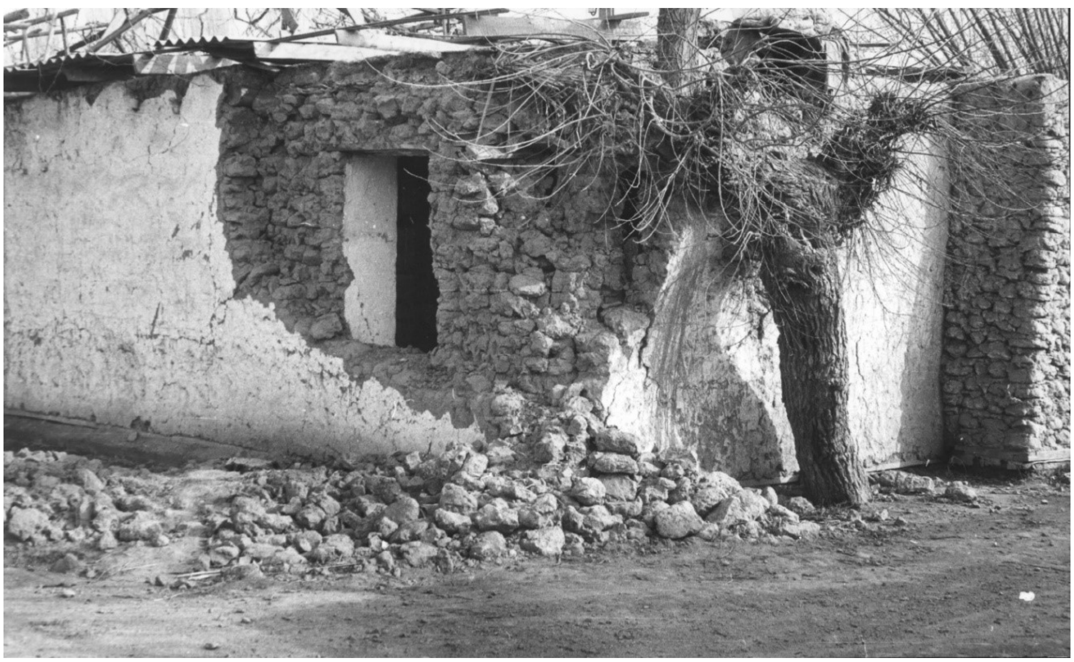


Figure A - 3

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Balvano Italy 1980**	1	2	3	4	5
●											●
TYPE OF STRUCTURE						**Fieldstone (in very weak mortar)**					

Figure A - 4

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Kurchum (Saisan) Kazakhstan 1990**	1	2	3	4	5
●	○								●	○	
TYPE OF STRUCTURE						**Brick masonry (bad quality)**					

Comment:

Class of vulnerability between A and B; the bad quality of the material, the insufficient strength of primary load-bearing elements (footings) and the lack of sufficient diaphragm action of floor slabs suggest more to vulnerability class A.

Figure A - 5

<table>
<tr><td colspan="6">CLASS OF VULNERABILITY</td><td>EARTHQUAKE / SITE</td><td colspan="5">GRADE OF DAMAGE</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td rowspan="2">Kurchum (Saisan)
Kazakhstan 1990</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>○</td><td>●</td><td></td><td></td><td></td><td></td><td></td><td>●</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">TYPE OF STRUCTURE</td><td colspan="6">Brick masonry</td></tr>
</table>

Figure A - 6

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Montenegro Yugoslavia 1979**	1	2	3	4	5
	●									●	
TYPE OF STRUCTURE						**Simple stone masonry**					

Figure A - 7

<table>
<tr><td colspan="6">CLASS OF VULNERABILITY</td><td>EARTHQUAKE / SITE</td><td colspan="5">GRADE OF DAMAGE</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td rowspan="2">Montenegro
Yugoslavia 1979</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td>●</td><td>○</td><td></td><td></td><td></td><td></td><td></td><td>●</td><td></td><td></td></tr>
<tr><td colspan="6">TYPE OF STRUCTURE</td><td colspan="6">Simple stone masonry</td></tr>
</table>

Figure A - 8

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Leninakan Armenia 1988**	1	2	3	4	5
	●								○	●	
TYPE OF STRUCTURE						**Stone masonry ("Midis")**					

Comment:

Grad of damage between 3 and 4, with tendency to 4: The wall element which failed was more vulnerable than the whole building. Damage is mainly caused by the lack of perpendicular stiffening walls or the length of wall and height of building. Damage of grade 4 can be classified: complex failure of external and internal walls and roof, also affecting other parts of the building.

Figure A - 9

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Leninakan Armenia 1988**	1	2	3	4	5
	●									●	
TYPE OF STRUCTURE						**Stone masonry ("Midis")**					

Comment:

Damage is mainly caused by the separation from the outer walls, the absence of ties at the corners and wall connections and the lack of efficient bonding; the longitudinal walls are not affected (see windows) so that an overestimation of intensity should be avoided.

Figure A - 10

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Kairakkoum Tadjikistan 1985**	1	2	3	4	5
	●							●	○		
TYPE OF STRUCTURE	**Brick masonry**										

Comment:

Grade of damage between 2 and 3, tending to 2; large and extensive cracks were present, but only in some walls; in regions with falls of fairly large pieces of plaster no significant cracks could be observed; the final decision depends on the entire structure and the damage of inner walls.

Figure A - 11

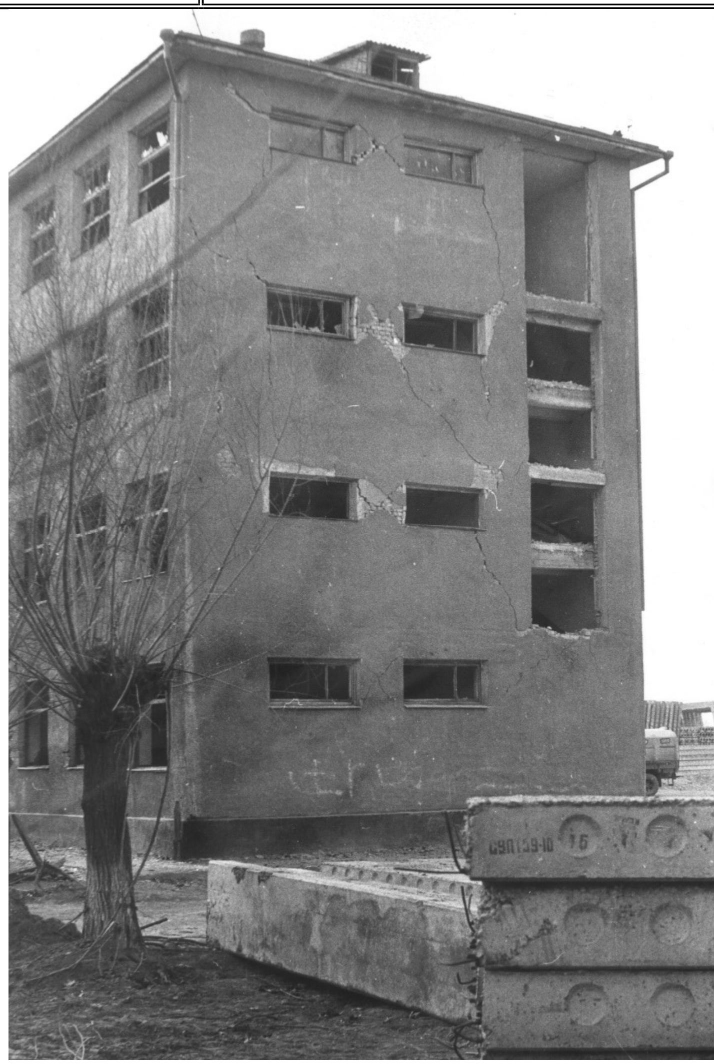
CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Kairakkoum Tadjikistan 1985**	1	2	3	4	5
	●							●	○		
TYPE OF STRUCTURE						**Simple stone masonry (“Midis”)**					

Comment:

System “Midis”: partially dressed tuff stone masonry; squared and cut; outer and inner shell; inner surface of stones is uncut to reach better bond (toothing).
(see **Figures A – 9**, **A – 10**)

Figure A - 12

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Kairakkoum Tadjikistan 1985**	1	2	3	4	5
	●								●		
TYPE OF STRUCTURE						**Brick masonry**					



Comment:

Grade of damage 3; large and extensive cracks in most walls.

Figure A - 13

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**El Asnam Algeria 1980**	1	2	3	4	5
		●									●
TYPE OF STRUCTURE						**RC frame and brick infill walls**					

Comment:

Clear situation with respect to grade of damage.
The structure was designed against seismic loads (low level of ASD), but there are such serious defects within the design (weak of soft ground floor) that the vulnerability class has to be reduced. Vulnerability class C seems to the appropriate.

Figure A - 14

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**El Asnam Algeria 1980**	1	2	3	4	5
		●	○						●		
TYPE OF STRUCTURE						**RC frame and brick infill walls**					

Comment:

Grade of damage 3: The outer shell of the brick walls possesses no intrinsic strength and fell off. The figure indicates the bad quality of bonding and only heavy damage on nonstructural elements; there are no remarkable cracks in the plaster in other walls. The building has a low level of ASD. It is irregular in ground plane. Vulnerability class C seems to be appropriate.

Figure A - 15

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**San Angelo Dei Lombardi Italy 1980**	1	2	3	4	5
			●	○			●		○		
TYPE OF STRUCTURE						**RC frame with moderate level of ASD**					

Comment:

Building with good structural properties: strong columns and brick with high strength lead to a less vulnerable building type.

Figure A - 16

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Artegna (Friuli) Italy 1976**	1	2	3	4	5
	○	●							○	●	
TYPE OF STRUCTURE						**RC frame and brick infill walls**					

Comment:

Building incorporating a medium level of antiseismic design, but with many defects (weak ground floor, heavy roof) leading to very vulnerable structure. Vulnerability class should be B or C depending on the regularity and quality of workmanship.

Figure A - 17

<table>
<tr><td colspan="6">CLASS OF VULNERABILITY</td><td>EARTHQUAKE / SITE</td><td colspan="5">GRADE OF DAMAGE</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td rowspan="2">Campania-Basilicata
Italy 1980</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td></td><td>○</td><td>●</td><td></td><td></td><td></td><td></td><td>○</td><td>●</td><td>○</td></tr>
<tr><td colspan="6">TYPE OF STRUCTURE</td><td colspan="6">RC structure with moderate level of ASD</td></tr>
</table>

Comment:

Unfinished hospital with moderate level of ASD (base shear of 0.07 g according to the building code); the L-shaped (irregular) ground plane suggests a lower vulnerability class.

Figure A - 18

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Mexico City 1985**	1	2	3	4	5
		○	●							○	●
TYPE OF STRUCTURE						**RC structure with moderate level of ASD**					

Comment:

RC building incorporating a medium level of ASD, but the vulnerability class is not higher than D: the building is irregular with respect to stiffness distribution (differences in each storey due to the extensive window-bands).

Figure A - 11

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Mexico City 1985**	1	2	3	4	5
		○	●							○	●
TYPE OF STRUCTURE						**RC structure with moderate level of ASD**					

Comment:

RC frame structure designed against seismic loads and, therefore, incorporating a medium level of ASD; but a vulnerability class of B has to be taken: insufficient spatial coupling between beams and colums; serious defects in construction, quality of workmanship and strength of material; misinterpretation of seismic hazard and underestimation of seismic loads.

Figure A - 20

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**Mexico City 1985**	1	2	3	4	5
			●	○					○	●	
TYPE OF STRUCTURE						**RC minimum level of ASD**					

Comment:

RC frame structure incorporating a medium level of ASD, but the system indicates irregularities with respect to the continuity in the line of horizontal beams.
The non-structural damage would suggest a grade of damage between 3 and 4, tending to 3; a detailes internal inspection might increase the damage to grade 4.

Figure A - 21

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**San Angelo Dei Lombardi Italy 1980**	1	2	3	4	5
			●	○					○	●	
TYPE OF STRUCTURE						**RC frame and brick infill walls**					

Comment:

Building with moderate level of antiseismic design. The ground plane is of minor global regularity. The brick infill is not well separated from the load-bearing RC frame, leading to very heavy non-structural damage.

Figure A - 22

CLASS OF VULNERABILITY						EARTHQUAKE / SITE	GRADE OF DAMAGE				
A	B	C	D	E	F	**El Asnam Algeria 1980**	1	2	3	4	5
				●			●				
TYPE OF STRUCTURE						**RC walls minimum level of ASD**					

Comment:

RC wall structure with medium level of ASD. Buildings are under construction. There is only minor damage of grade 1. (The collapsed buildings in front of the photo are from other building type.)

Figure A - 23

<table>
<tr><td colspan="6">CLASS OF VULNERABILITY</td><td>EARTHQUAKE / SITE</td><td colspan="5">GRADE OF DAMAGE</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td rowspan="2">Kairakkoum
Tadjikistan</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td></td><td></td><td>●</td><td>○</td><td></td><td></td><td>●</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">TYPE OF STRUCTURE</td><td colspan="6">RC (prefabricated) with large panel walls</td></tr>
</table>

Comment:

RC large panel apartment building with a low level of ASD. The detail shows horizontal cracks in the joint of panels.
During a sequence of different earthquakes n the former U.S.S.R. this type of building suffered only minor damage and justifies denotation of vulnerability class D or higher.

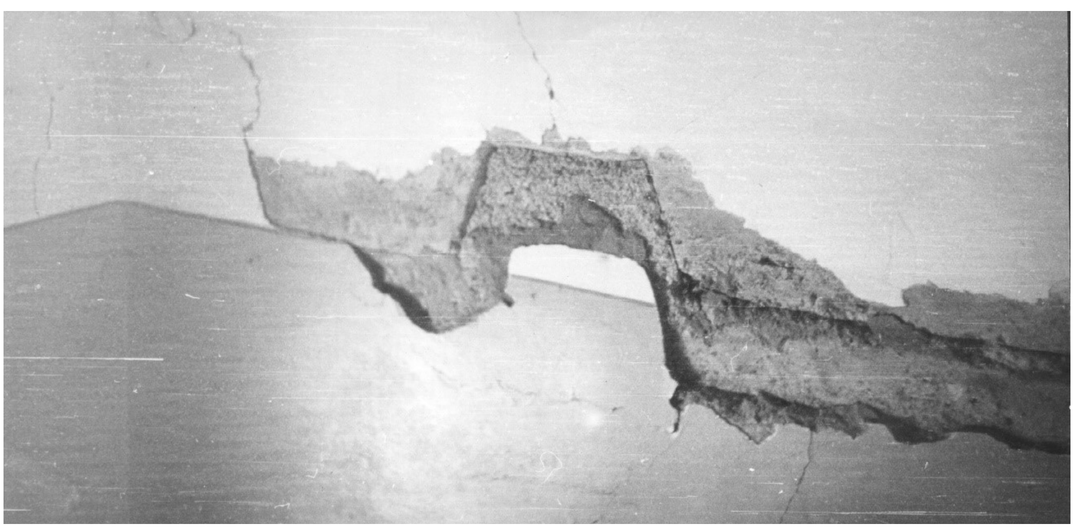


Figure A - 24

References of photographs:

Figures A-1 - 3, A-6, A-9, A-11 - 13, A-24 by E.T. Kenjebaev and A.S. Taubaev (Alma-Ata);

Figures A-4, A-7, A-8, A-10, A-14 - 23 by H. Tiedemann (Swiss Reinsurance Company, Zürich);

Figure A-5 by J. Schwarz (College of Architecture and Cilvil Engineering, Weimar).

ANNEXE B
ENGINEERED STRUCTURES (BUILDINGS

Contents

B.1 Types of engineered structures (buildings)

B.1.1 Introductory remarks (code situation)

The description and classification of engineered buildings can be based on different qualitative parameters.
In seismic codes engineered buildings are subdivided according to
- their **main (primary) structural system** (frame, wall, core or dual systems)
- their **structural material** (steel, reinforced concrete, wooden or masonry) or
- a combination of both (**structural system and structural material)**.

Furthermore, engineered buildings are classified according to their
- **importance**
- dynamic characteristics, expressed in terms of **regularity or symmetry**
- ability to withstand seismic loads in the inelastic range, expressed in terms of **ductility**.

For the purpose of scale, it is impossible to give a classification of engineered buildings, reflecting differences and refinements within national seismic codes.
Additional types of buildings (structures) are introduced to cover the national differences and to assure direct correlations with intensity scale (see B.1.4).

The performance of buildings is dependent on
- the level of earthquake resistance (quality) and
- the level of regularity of buildings.

and this must be taken into account when evaluating intensity. These parameters should also be considered in the case of buildings that are not antiseismically designed.

B.1.2 Levels of quality

For application of the Annexe B the buildings have to be classified according to their **level of quality.** This means a classification of the level of earthquake resistance has to be introduced, taking into account the quality of workmanship, the strength and quality of material used and the intended level of resistance / protection.

The used **levels of quality** are:
- Q_l : low
- Q_m: medium
- Q_h : high

These levels can differ between different countries. They are also non-uniform with respect to the level and the aims of national earthquake regulations.

Level Q_l is still the dominant level of resistance in most of Europe. The classification of intensity degrees (section B.4) is mainly related to this level.
Level Q_h is typically for countries like Japan or New Zealand and will seldom be reached in Europe.

B.1.3 Level of regularity

With respect to current code developments (Eurocode No 8) engineered buildings have to be classified according to their structural regularity.

The used **levels of regularity** are:
- R_l: low
- R_m: medium
- R_h: high

The **level of regularity** can be defined on the basis of
- global parameters (dimensions, ratios of geometry);
- global and local deviations of regular ground plane and vertical shape;
- parameters of the building, determining dynamic characteristics (stiffness and mass distribution); and
- quality of energy transformation and dissipation, ensured by coupling between ground, foundation and structural elements and by avoiding critical local concentrations of damage (plastic hinges).

Regularity should be considered in a global sense, i.e., regularity is more than just external symmetry in plan and elevation. Regularity in the sense used by this draft includes characteristics of a building and also measures within it to ensure a simple or, in a limited extent, controlled behaviour under seismic action. It is intended that regularity corresponds with rules of earthquake resistant design.

The level R_h, commonly not reached in European countries, should be characterised by
- improved ductility of structural system and
- active controlled mechanism of plastification as result of a special antiseismic measures.

B.1.4 Level of antiseismic design

Introductory remarks
With respect to the quality of antiseismic design engineered structures (buildings) can be subdivided into three main groups:
- Group 1: buildings with special antiseismic measures (base isolated buildings or special structures)
- Group 2: buildings with antiseismic design, i.e., buildings designed and built according to the scope of codes (design philosophy); the seismic hazard assessment and elaborated zoning map (different zones) and the parameters describing seismic action for different seismic zones
- Group 3: buildings without antiseismic design, i.e., buildings designed and built according to modern design principles and codes (concrete, masonry etc.)

Observations from buildings of group 1 should not be used (see also sect. 2.4.1).
Observations from buildings of group 2 can be expected in earthquake regions where the design of buildings has to take into account earthquake resistant regulations.

Observations from buildings of group 3 can be expected in regions with negligible or low seismicity where earthquake resistant regulations are not existent or are present in a still recommendatory manner.

For assigning intensity engineered buildings of group 2 and 3 are considered and further specified.

Definition of type ASD_i

Assuming that buildings in an earthquake zone i are designed and built for a **design earthquake** of the intensity (or ground motion), matching site and subsoil conditions of the zone i, engineered buildings are classified according to the incorporated level of antiseismic design (ASD). The antiseismic design is ruled by national seismic codes.
The level of antiseismic design can be distinguished on the basis of intensity or other design parameters (peak ground motion, base shear) which are directly related to the seismic zone i.
Buildings of type ASD_i are specified for I = 7, 8 and 9; i is an expression for the intensity of the design earthquake.

As an example, a structure of type ASD_7 can be considered to be a structure designed according to seismic code provisions for an intensity of 7, or designed according to seismic code provisions for a design level which is comparable to the level of type ASD_7. In zones of intensity 6 no or only constructional demands will be established.

The types ASD_i can be classified as follows:

Type ASD_7: Engineered buildings incorporating a **minimum level** of antiseismic design.
This level is characterized by the limitation of structural parameters and a simplified method of calculation. Depending on the importance of building it may be permitted to ignore additional seismic loads. Special measures of detailing (to improve ductility) are not typical for this building type. This type is widespread in areas of low or moderate seismicity. (Commonly, buildings of this type are designed for an intensity of 7 or a base shear coefficient of *3 - 4 % g*.)

Type ASD_8: Engineered buildings incorporating a **moderate (improved) level** of antiseismic design.
This level is characterized by the realisation of design rules. Special measures of detailing (to improve ductility) are partially implemented. This type is to be expected in areas of moderate to high seismicity. (Commonly, buildings of this type are designed for an intensity of 8 or a base shear of about *5 - 6 % g*.)

Type ASD_9: Engineered buildings incorporating a **high (qualified) level** of antiseismic design.
Seismic loads are calculated by dynamic methods. Special measures of detailing are provided to ensure a ductile system where the seismic energy is distributed all over the structure and is mainly dissipated in plastic hinges without structural failure. This type should be expected in areas of high seismicity. (Commonly, buildings of this type are designed for an intensity of 9 or a base shear of about *8 - 12 % g*)

Definition of type EASD:
Assuming that engineered buildings of modern structural system and material (reinforced masonry, steel and reinforced concrete frames) and well-built wooden structures, not designed against lateral seismic loads, can provide a certain level of earthquake resistance and assuming that this level can be comparable to the level incorporated in engineered buildings with antiseismic design (ASD_i), buildings of this type are classified according to their level of regularity (sect. B.1.3.) and their level of quality (sect. B.1.2).

Type EASD: Engineered buildings incorporating a **limited or equivalent level** of antiseismic design.

The level of antiseismic design is relatively uniform within an earthquake region for which intensity has to be assigned. The level can be non-uniform when buildings within an earthquake region are designed for different codes (old, up-dated, new).

B.1.5 Importance of buildings

The importance of engineered buildings has to be taken into account for the different levels of antiseismic design (ASD). The importance of a building is determined by the number of occupants or visitors, the use of the building (or the consequences of interruption of the use) or the danger for public and environment in the case of the building's failure.

The classification of importance is not harmonized and also quite different in different European earthquake regulations, and is connected with the definition of seismic load amplifying factors.

In special cases buildings of higher importance are designed for loads which are typical for a higher intensity class. Buildings of high importance or higher risk potential should be carefully considered with respect to the final level of design loads.

B.2 Definition of quantity

Figure B-1 shows the typical frequency distributions of damage grades for damaging intensity degrees without specifying the different types of buildings. The description of intensity is limited to special intersecting points (between the higher grades of damage and the values of damage probability function) of this frequency distribution. In effect, the severity of damage and the probability of its occurrence form a continuum from which sample points (expressed as quantities such as "few", "many" and "most") are used to describe intensity (sect. 3.2).

In the right column of Figure B-1 symbols describing quantities of the probability of occurrence of damage are introduced (see sect. B.4, **Table B-1**.). As it is illustrated in Figure B-1, intersecting points between the lower grades of damage and the values of damage probability functions are used for assigning intensity degrees.

B.3 Classification of damage

Damage Grades 1 to 5 correspond to those in the core scale (sect. 3.1.3), as given for modern (reinforced concrete) buildings. Locations of damage and damage patterns are different for engineered and non-engineered structures.

One should carefully distinguish between
- damage to the primary (load- bearing/ structural) system;
- damage to secondary (non- structural) elements (like infills, curtain walls);
- damage in special (therefore provided) plastification zones (coupling beams in wall structures, joints in buildings of prefabricated wall elements or beams in joints of frame structures).

The classification of structural damage should be evaluated in the most severely damaged storey of a building. Damage caused by mutual pounding of adjacent building with insufficient separation should not be taken into account.

B.4 Intensity degrees

Note:
The description of intensities is based on the analysis of engineered buildings with earthquake damage (damage surveys) under the following scaling conditions:
- buildings of type ASD_i: a level of regularity of R_m and
  a level of quality of Q_l
- buildings of type EASD: a level of regularity of R_m and
  a level of quality of Q_m

The classification of intensities can be based on two approaches.
The **first** approach is consistent with definitions of intensity degrees in 3.2. Therefore, on the basis of the idealised characteristics of ASD_i type structure (B.1.4) the actual level of ASD has to be predicted and has to be expressed in terms of vulnerability classes.

For the assumed scaling conditions, it can be stated that:
- type ASD_7 is comparable with the vulnerability class C,
- type ASD_8 is comparable with the vulnerability classes C and D,
- type ASD_9 is comparable with the vulnerability classes D and E,
- type EASD is comparable with the vulnerability class C.

The **second** approach is related to available results of damage surveys. Such results are transformed in Table B-1 for engineered structures (buildings) with a level of regularity R_m

and a level of quality Q_l. Appropriate descriptions for other scaling conditions (i.e., other levels of regularity and/or quality) can be introduced following the scheme given in Table B-1.
Table B-1 provides information about quantities of damage grades for intensity degrees. These, or similar, more representative descriptions can be inserted in 3.2 and could replace the tentative definitions (in italics). The second approach can be regarded as an attempt to calibrate vulnerability classes on the basis of observations for their typical representatives.

B.5 Comments on the assignment of intensity from engineered structures

B.5.1 Definition of regularity

The classification of regularity should follow principles stated in national earthquake resistant regulations. The restriction on the height of buildings to be used for intensity assessment is not required in the case of engineered structures. The height of buildings is of importance when the regularity of a building has to be evaluated.

The height of buildings is considered in seismic codes
- directly, by defining limits of height or of storeys, and/ or
- indirectly, by defining limits of slenderness (ratio of height to plane dimensions).

In European earthquake codes the height of regular buildings is limited to 30-40 metres; the slenderness ratio (height to width) should not exceed 4.0-6.0. Special design methods and detailing have to ensure earthquake resistance in the case of irregular structures.

B.5.2 Factors contributing to damage

When assessing intensity using non-engineered structures and modern engineered structures (buildings), one should consider the essential factors contributing to damage or to an increase of damage. Otherwise, a misleading interpretation of the actual situation can occur resulting in an overestimation of intensity.

Some of the most important damage contributing factors are (besides the regularity, the quality of materials/ workmanship, which are already implemented through the classification of **levels Q and R**):

a) the quality of subsoil and hardness of foundation material, and the potential for soil liquefaction;
b) the dynamic characteristic of building, the predominant frequency content of ground motion, mainly determined by subsoil conditions, distance and depth of the earthquake source and the type and amount of energy release (magnitude);
c) resonance conditions between the building and the ground motion and its agreement or

relation with the amplification effects considered and expressed in code design coefficients;

d) the ability of the building to dissipate seismic energy and to react in postelastic range without collapsing (this factor is commonly quantified in terms of ductility or structural behaviour factor);
e) the stiffness of the building to limit deformations and damage to non-structural elements;
f) the orientational sensitivity of buildings with different dimensions and stiffness in the perpendicular axis of ground plane;
g) **soil behaviour**
   The influence of subsoil conditions should be taken into account with respect to design assumptions, i.e., when the frequency content of the actual earthquake differs significantly from that of the design earthquake in the range of dominating building periods (or equivalent terms) when the demands are greater than the resistance capacity provided by antiseismic design (ASD).

B.5.3 Special remarks to the classification of damage and intensity degrees

The progression of damage with intensity degrees does not increase linearly in the case of engineered structures (buildings), introduced as types ASD_i. This can be justified with respect to modern design principles which are related to the performance of engineered structures under different levels of design earthquake (intensity):

- Structures designed against an earthquake of low intensity to be expected with high probability of occurrence, should sustain such an event without structural damage and with no damage, or only minor damage, that could affect the serviceability.
- Structures designed against an earthquake of medium intensity to be expected with low probability of occurrence, are explicitly allowed to react under the design earthquake with slight non-structural damage, but should survive without loss of serviceability
- Structures design against an earthquake of high intensity, have to sustain structural damage without loss of structural integrity and stability.

This means that structures in zone i, designed for intensity I, will show higher grades of damage in seismically more active regions. On the other hand, one may postulate that there are no differences in the aim of protection for structures of different structural systems when these buildings are classified into the same importance category (of the national seismic code).

B.5.4 Relation between intensity and other earthquake zone related design coefficients

The definition of ASD_i types of engineered structures is based on intensity and on other earthquake zone related design parameters (e.g., the base shear coefficient).
It is necessary to establish relations between ASD_i type structures (buildings) of this draft and antiseismic buildings designed

- according to the different seismic codes
- for different (classified and subdivided) seismic zones and
- for quite different design loads and protection levels.

Furthermore, it is necessary to compare design levels of antiseismic structures in each country with the idealized characteristics of ASD_i types expressed in terms of design intensity or other zone related design coefficient. The relation between intensity and other earthquake zone related design coefficients should be considered as a matter of further discussion. Therefore, the base shear in B.1.4 is given in italics to indicate the tentative character.

B.6 Brief examples for application

B.6.1 Non-engineered structures

In a town, damaged after an earthquake, 40% of unreinforced brick buildings with reinforced concrete floors suffered grade 3 damage.
The first question to be answered is, to what class of vulnerability the buildings used for intensity assignment belong. The buildings are of good quality, regularity, and workmanship. So, they can be regarded as vulnerability class C.
Following the definition of intensity degrees in 3.2, an intensity of IX can be assessed.

B.6.2 Engineered structures

General procedure

(1) It is possible to predict the *code-consistent level* of ASD and with this to evaluate the ASD_i type(s) of engineered buildings in the study area on the basis of the seismic zone defined within the national seismic building code. Commonly, each region or town is characterized by one ASD_i type only; but for the assignment of intensity, it is necessary that information is available which indicate the distribution or individual sites of those buildings. A region or town can be characterized by different ASDi types when buildings are present which were built according to different seismic codes.
(2) It is necessary to predict the *actual* level of ASD and to qualify the level of regularity as well as of the quality of workmanship of engineered buildings in the study area. Furthermore, it is necessary to compare design levels of antiseismic structures in the earthquake region with the idealized characteristics of ASD_i types of this draft expressed in terms of design intensity or other zone related design coefficients.

(3) The present draft of Annexe B offers two approaches to assign intensity.
- The first approach is directly related to the classification of intensity in the Core part of the scale. For this it is necessary to predict the typical or representative vulnerability class(es) for the actual ASD_i type(s) of the engineered buildings in the study area. The intensity can be classified on the basis of the predicted vulnerability class(es) and the definitions of intensity degrees (see 3.2).
- The second approach is related to available results of damage surveys, which are incorporated in Table B-1 (derived for engineered structures with medium level of regularity and low level of quality). This table alone would be sufficient for establishing of the scaling conditions of intensity. (In the framework of the present version of the EMS, Table B-1 should provide background information for the determination of vulnerability classes of ASD_i types; i.e., this Table contains the basic information for the intensity definitions using vulnerability classes D - F given in *italics* in 3.2).

Both approaches require the classification of the level of regularity and of the quality of the ASD_i type structures.

Example

In a town, damaged after an earthquake, 30% of the engineered buildings suffered damage of grade 2; 5% suffered damage of grade 3.
According to the zoning map of the seismic code the town lies in a zone of design intensity 8 (zone with medium seismic hazard; base shear of 6%g). Earthquake forces were incorporated into the design using calculations by simplified dynamic methods. The zone-consistent ASD_i type of the engineered buildings is type ASD_8.
The buildings have a medium level of regularity, a low level of workmanship but no other design deficits ("defects"). There are no essential differences between design loads and the characteristics of strong ground motion of the actual earthquake. The actual ASD_i type is ASD_8.
According to B.5.1 type ASD_8 is comparable to vulnerability classes C and D (for the level of regularity R_m and the quality level Q_l).
Following the intensity degrees in 3.2, the intensity is VIII for vulnerability class C and IX for vulnerability class D. It can be concluded that the intensity was VIII - IX. (In reality not only damage to engineered buildings should be taken into account but also the other diagnostics arranged under a) and b) of the intensity definitions.) According to the damage surveys incorporated in Table B-1 one can conclude that the intensity tends to be more VIII than IX, because a higher percentage of buildings with damage grade 3 would be expected for intensity IX.

B.7 Suggestions for improvements

For the application and improvement of this Annexe it is suggested to introduce the following tables:
- ***Table B-2****, within which European countries and their seismic codes should be evaluated according to the levels of earthquake resistance provided*
  (necessary to select the appropriate **level of quality** (sect. B.1.2));

- ***Table B-3****, within which qualitative indicators and criteria for the classification of regularity should be illustrated according to modern design principles, proposed in the actual/final edition of the Eurocode 8*
  (necessary to select the appropriate **level of regularity** (sect. B.1.3));

- ***Table B-4****, within which simple illustrations should be given with respect to different behaviour and damage pattern of regular and irregular structures*
  (have to be completed by figures of damaged buildings and should also illustrate typical structural types and systems in various earthquake regions. It seems to be useful to add these tables, as a second part, to the Annexe A: "Examples illustrating classification of vulnerability and damage used in the scale").

Tables B-2, B-3 and B-4 *are not included in the present draft of the EMS (MSK-92)*.

Tables B-2 - B-4 have to be developed and introduced according to the results of discussion among national specialists and their proposals. **Table B-1** has to be compared with results from engineering analysis of structural damage in European and other earthquake regions. Tables have to be introduced for other levels of quality and/or regularity. Vulnerability functions for different types of structures (similar to the idealized ones in **Figure B-1**) should be evaluated for engineered structures in dependence on the proposed levels of antiseismic design.

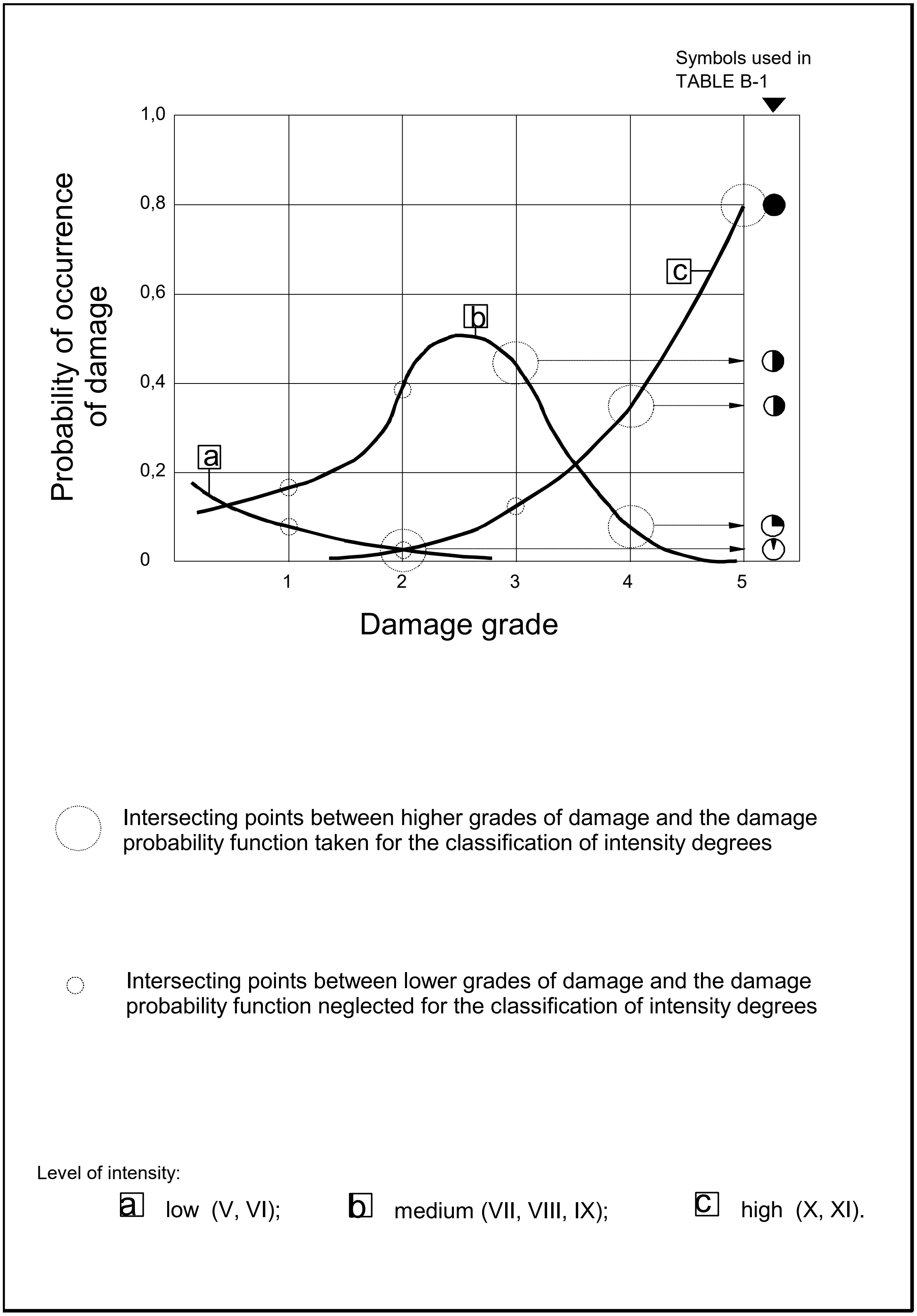


Figure B-1 Relation between typical frequency distributions of damage grades for different intensity degrees and definitions used in the presented intensity scale.

INTENSITY	TYPE	LEVEL Q_l				
		Damage Grade				
		1	2	3	4	5
VI	ASD_7	few	very few			
	ASD_8	few				
	ASD_9	very few				
VII	ASD_7	many	few			
	ASD_8	many	very few			
	ASD_9	few				
VIII	ASD_7	few	many	few		
	ASD_8	many	many	very few		
	ASD_9	many	few			
IX	ASD_7				few	
	ASD_8		many	many	very few	
	ASD_9		many	few		
X	ASD_7				many	few
	ASD_8		few	many	many	very few
	ASD_9			many	few	
XI	ASD_7					many
	ASD_8				most	many
	ASD_9				many	few
XII						

very few   few   many   most

Table B-1 Relation of damage grades to intensity degrees for ASD_i type buildings of low level of quality Q_l and medium level of regularity R_m.

ANNEXE C
SEISMOGEOLOGICAL EFFECTS

The effects of earthquakes on the ground, here summed up as “seismogeological” effects, have often been included in intensity scales but are in practice quite hard to use to advantage. This is because these phenomena are complex, and are often influenced by various factors such as inherent slope instability, level of water table, etc, which may not be readily apparent to the observer. The result is that most of these effects can be seen at a wide range of intensities.

For the purposes of this up-dated scale version, these effects are presented as a table; for each effect, three different signatures are drawn to show:

lines - the possible observation range;
open circles - the range of intensities that are typical for this effect;
full dots - the range of intensities for which this effect is most usefully used as a diagnostic.

These lines are terminated in arrows to show a potential for extreme observations even beyond the limits shown in exceptional cases, different geological settings, or special sensitivity. For some effects, not all three categories are plotted where there is thought to be inadequate experience to formulate an opinion.

It should be remembered that for most of these effects, the severity of the observation will increase with higher intensity. Thus for “flow of springs affected”, at intensity 5 one might expect slight change in spring flow, while at higher intensities the change may be very much greater. It was decided that attempting to discriminate between “slight change in flow of springs” and “great change in flow of springs” within the scale was not practical owing to the difficulties in quantifying such expressions.

Care must be taken, especially when dealing with ground breaks, to discriminate between geotechnical observations, i.e., those caused by shaking, and neotectonic observations, i.e., those caused directly by fault rupture.

The effects listed in the table are grouped in four categories: hydrological, slope failure, horizontal ground processes and convergent processes (complex cases). This latter group covers instances where more than one type of process is involved in producing the effect. It will be noted that landslides appear both as slope failure effects and convergent processes effects. This is because some landslides are straightforwardly the result of shaking dislodging rocks, whereas others only occur because slope instability is compounded with certain hydrological conditions. Discriminating between these may not be easy; this is an illustration of the problems that arise in dealing with this sort of effect.

Table C-1: Relation of Seismogeological Effects to Intensity Degrees

Seismogeological and hydrological effects	Intensities											
	1	2	3	4	5	6	7	8	9	10	11	12
Hydrological effects												
level of well water - minor changes)1	●	●	○	○	○	○	—	—	—	→		
level of well water - substantial changes)2						●	●	●	—	—	→	
long period waves on standing water)3	—	—	—	—	—	—	→					
waves on standing water from local shaking						●	●	●	—	→		
lake water made turbid 4)		←	—	—	—	—	○	○	○	—	—	—
flow of springs affected 5)				←	○	●	●	—	—	—	—	—
springs stop and start						←	●	●	●	—	—	—
water thrown from lakes										←	—	—
Slope failure effects												
scree slopes move					←	●	●	—	—	—	—	—
small landslips)6					●	●	●	—	—	—	—	—
minor rockfalls) 7					←	●	●	○	—	—	—	—
landslides, massive rockfalls							●	●	●	●	●	●
Horizontal ground processes 8)												
minor cracks in ground					←	●	●	●				
large fissures in ground								●	●	●	●	●
Convergent processes / complex cases												
landslides (hydrological) 9)					●	●	●	●	●	●	●	●
liquefaction 10)							←	●	●	●	●	●

Legend: ●—● most useful range as intensity diagnostic; ○ intensities also typical for this effect; —— possible observation range; ——→ potential for extreme observations beyond the given limits

Notes to the Table on Seismogeological Effects

[1] detected by automatic instruments only
[2] easily observed changes
[3] resulting from distant earthquakes; possibly with wave-induced turbidity
[4] from disturbance of bottom sediments
[5] rate changes or spring water made turbid
[6] in loose material in natural (river banks etc.) or man-made (road cuttings) sites
[7] minor rockfalls in natural (cliffs) or man-made (rock cuttings, quarries) sites
[8] these two categories blur into one another. The warning is repeated about not confusing ground rupture breaks with fissures caused by shaking.
[9] Landslides with predominant hydrological causes (may be delayed effects)
[10] Liquefaction (e.g., sand craters, mounds formed, etc.)

ANNEXE D
EXAMPLES OF INTENSITY ASSIGNMENT

EXAMPLE 1 - FROM DOCUMENTARY DATA

The following two descriptions are of the effects of an earthquake on 7 September 1801 at Comrie, in Scotland. Both are taken from contemporary Edinburgh newspapers. Edinburgh was at that time the nearest place at which newspapers were published. The distance from Comrie to Edinburgh is about 75 km. The time of the earthquake was about 6 am.

The following account was written by an observer in Comrie, on 9 September, two days after the earthquake. It was published in the Edinburgh Advertiser (15 September 1801 p174).

1) The ... shock ... was very great, and alarming beyond expression. ... Slates fell from some houses, and many loose bodies tumbled down with great precipitation. Sonorous bodies were dashed on each other, and rang loudly, such as bottles, glasses, &c. Several large stones and fragments of rocks fell down the sides of the mountains. Pieces of stone dykes fell, and one bank of earth slid from its place. If the shock had had a little more impetus, it is probable, several frail houses would have been thrown down; but, in the kindness of Providence, no farther harm hath been done than what is above stated.

The second account was also written at Comrie on 9 September, and was published in the Edinburgh Evening Courant (14 September 1801, p3).

2) ... the noise and shock ... were instantaneous; all those persons who were in bed were terrified that their houses were tumbling down about their ears, and many here and in the neighbourhood jumped out as quickly as possible - its duration might be about five or six seconds, and during all that time the floors, beds, and window shutters shaked violently, and the roofs creaked and strained at a great rate. The horses that were grazing seemed much frightened and to listen with their ears pricked up; the cows also that were housed appeared, from their lowing, to be very uneasy, and all the dogs and other animals gave signs of fear. A shepherd, a few miles to the westward, had just separated a flock of cattle, but as soon as the earth began to tremble, they all crowded together in a moment.

Commentary

These two descriptions are quite useful, and contain more information than is often the case for effects in a small village (population in 1801 was about 1500) from a moderate earthquake in this period.

A word needs to be said first about local building type, which would have been predominantly stone-built houses (usually single-storey), with timber roofs covered with slates. These can be considered as vulnerability class B structures. The strength of these buildings is likely to have been quite good, where not affected by disrepair.

A first indication of the intensity degree is usually obtained by looking at the damage. Here the damage is evidently slight, and is not mentioned at all by the second writer. The principal effect observed is the falling of slates from some houses. This is technically grade 3 damage, but since there is no evidence of other types of grade 3 damage (to chimneys or walls) it is likely that those slates that fell were loose. There is no mention of cracks to plaster, but these often go unmentioned (a) because they are not observable from the outside of the building (b) they may not be noticed by the house owner until later, especially if there are other pre-existing cracks. Therefore, the absence of mention of damage to plaster is not very significant. The lack of mention of damage to chimneys, which are a prominent feature, is much more significant, especially when the first writer specifically says that no more damage occurred than what he described. The fact that some very weak houses did not fall down is also mentioned specifically.

The first conclusion to be drawn, from a consideration of the damage, is that the intensity is at least 5, but not more than 6. For the intensity to be 7 it would be necessary for there to be more evidence that many houses were damaged, especially their chimneys. This is not the case.

The "stone dykes" referred to here are boundary walls. This type of structure is not dealt with by the MSK intensity scale as such, but experience shows that this type of damage begins at intensity 5.

Considering effects on people, both accounts agree that the shock was very frightening. People were terrified expressly that their houses were falling. Many jumped out of bed - it is not said that they ran out of doors, but it seems likely, and in this case probably the description fits best with "many people are frightened and run outdoors" for intensity 6. It is clear that the earthquake was felt outdoors (e.g., by a shepherd) but not by how many. The effects on people confirm the possible range 5-6, with 6 being more likely.

The first account states that many articles were thrown down violently. This is much more like "small objects of ordinary stability may fall" (intensity 6) than like "small, top-heavy and/or precariously supported objects may be shifted or fall down" (intensity 5), and even resembles "objects fall from shelves in large numbers" (intensity 7).

The clashing of bottles, shaking of window shutters, etc., is an effect which begins at intensity 4 and continues to be observed at higher intensities. Here it is clear that the strength of shaking is at least 5.

The second writer mentions effects on animals. Cows indoors were uneasy (intensity 5) but horses and cattle outdoors were also alarmed (intensity 6).

The cumulative consideration of the above indicates that intensity 6 is the best assessment of the intensity at Comrie for the 7 September 1801 earthquake.

Some confirmation can be looked for from seismogeological data. The first writer mentions effects on slopes - large stones and fragments of rock slid down the mountains, and a bank of earth suffered a small slip. The first effect is more like movement of scree slopes than a rockfall, but both effects start at intensity 5 and are typical of 6-7 (6-8 in the case of rockfalls). The second effect is associated with intensities 5-7, but because it appears to be a solitary instance, it is not a very strong indicator. These effects confirm judgements made from an examination of the rest of the data.

EXAMPLE 2 - FROM QUESTIONNAIRE DATA

The following data are extracted from questionnaires relating to the effects of the 26 December 1979 Carlisle earthquake (magnitude 4.8 ML), at Carlisle in Northern England. The questionnaire was published in local newspapers; readers of the newspaper were invited to fill out the questionnaire and send it in. Random sampling techniques were therefore not followed in the collection of data, and percentages calculated from the sample are not guaranteed to be reliable indicators of the total population. The questionnaire was not designed with the MSK scale in mind, and therefore not all the questions relate closely to the text of the scale. In this example, therefore, the scale can be shown to work with data which are not optimal.

For the purposes of this study the city of Carlisle was divided into three areas. The data from the western part of the city are used in this example. The number of questionnaires received was 222 from this part of the city.

The time of the earthquake was 03h 57m; almost all observers were indoors and in bed. There were no reports from people outdoors, since the streets were deserted at this time of night, on the morning after Christmas Day.

Question: What did you feel?

87% felt some sort of vibration; 19% described it as strong (though they weren't specifically asked to qualify their description); 1% described it as weak; 11% felt no shaking.

Commentary: the vibration was generally observed or strong.

Question: What did others nearby feel or hear?
73% said their neighbours felt or heard the earthquake; 12% said they didn't and the remainder didn't know or didn't answer.
Commentary: the earthquake was felt by most people indoors.

Question: Were you frightened or alarmed?
69% said they were - 18% said they were not. Three people said they ran outdoors, but this information wasn't actually requested by the questionnaire, so more may have done so.
Commentary: many or most people were alarmed or frightened and at least a few tried to run outdoors. So far, the intensity looks to be in the range 5-7.

Question: Did doors or windows rattle?
54% said yes; 26% said no.
Question: Did anything else rattle?
54% said yes; 19% said no.
Commentary: the intensity is at least 4 and probably 5 or more from this evidence.

Question: Did any hanging objects swing?
14% said yes; 26% said no, and the rest had no hanging objects to observe, or couldn't see in the dark, or didn't answer.
Commentary: since the shaking from a relatively small earthquake at close range (as here) is likely to be of high frequency, it is not to be expected that there will be many observations of hanging objects swinging. In these circumstances the ratio of approximately 1:2 yes:no replies suggest quite strong shaking, i.e., at least intensity 5.

Question: Did anything fall over or upset?
18% said yes; 72% said no.
Commentary: The intensity was at least 5.

Question: Was there any damage?
13% reported damage of some sort; 85% reported no damage. Most of the damage was of cracks to plaster and walls; also fall of slates, fall of chimneys and loose bricks dislodged. In one case it was reported that a gap opened between a garage and a house extension.
Commentary: the type of housing is predominantly brick-built. The damage can be summarised as few vulnerability class B buildings suffer damage of grade 1 and 2. This does not match exactly the descriptions given in the scale, but is closer to that for degree 6 than anything else.

Question: Have you any other observations?
A variety of answers were received. Nine people reported that furniture was shifted, an effect first mentioned at degree 6 of the scale.

Summary: The intensity is best assessed as intensity 6 on the evidence above, although the assignment is marginal and some might argue for 5 or 5-6. The degree of damage, the shifting of furniture and the amount of people frightened suggests 6 and the rest of the data are at least consistent with this, though one might expect a higher percentage of observations of items falling.

I. Request for comments on the present version of the EMS Scale

Comments on, and questions about, the EMS Scale are welcomed by the Working Group. lt is intended that at the end of a three year trial period a further revision will be made to scale and the present draft will be refined according to feedback received during the three year period. As weil as general remarks on tbe Scale and Annexes, the Working Group is especially anxious to receive comments on the following areas:

i) Classification of building types; the specification of most likely vulnerability classes and probable ranges, especially with regard to engineered structures; further subdivision of building types (with respect to vertical and horizontal structural systems) or additional building types including special types in certain areas.

ii) Behaviour of buildings under earthquake shaking, with a view to refining the assessment of probabilities of damage given in italics for engineered buildings in this draft of the Scale.

iii) The evaluation of the level of earthquake resistance provided by seismic codes within European countries to select the appropriate level of quality or to define the code-consistent level of antiseismic design in Annexe B.

iv) Examples of the application of the Scale in practice, the result of damage surveys, and checks of the new Scale against previous versions of the MSK Scale to determine consistency.

All comments, suggestions for improvements or examples should be sent to the chairman of the Working Group and Editor:

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GeoForschungsZentrum Potsdam
Telegrafenberg, D-14473 POTSDAM

II. Editorial remarks to the Annexe A

Figures A-1 to A-13 illustrate examples for buildings without special antiseismic design; the vulnerability classes follow the probable range given in Table 1.

Figures A-14 to A-24 luve to be regarded in connection with Annexe B and the definition of a code-consistent level as weil as the actual level of antiseismic design (ASD). The dass of vulnerability is determined by the actual level of ASD; the type of structure represents the code-consistent level, which should be expected in dependence on design parameters (intensity, ground motion, base shear).

After finishing of the editorial work it proved to be tbat some headings in the following Figures are misleading or incomplete. The classification of types of structures, in accordance with the comments, should be corrected as follows:

- Figures A-14, A-15: Type of Structure: R.C. with minimium ASD,
- Figures A-21, A-22, A-23: Type of Structure: R.C. with moderate ASD,
- Figure A-24,: Type of Structure: R.C. with moderate ASD (in the comment: moderate level ASD instead of low level ASD).