SECED
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SECED MEETING REPORT SUPPLEMENT

GROUNDBORNE VIBRATION AND STRUCTURAL DAMAGE

In this supplement, a report on an informal SECED meeting held in September at the Institution of Civil Engineers is outlined on the subject Groundborne Vibration and Structural Damage - Presentation of New British Standards. The meeting heard Bryan Skipp (Soil Mechanics Associates) review current developments on the subject within the International Standards Organisation and David Malam (WS Atkins Science & Technology) report on a valuable study re-examining data on which the new standards are based. In David Malam's talk the causes of structural damage and vibration were reviewed, the results on an interesting case-history study in the UK (1986-1988) presented, and the current status of BS 7385: Measurement and Evaluation of Vibration in Buildings examined. A selection of a few of David Malam's overheads are reproduced in this supplement - a full set may be obtained from the SECED Secretary, Louise Picton, at the Institution of Civil Engineers, Great George Street, London SW1P 3AA. Firstly, Bryan Skipp reports on the current position in the ISO scene.

VIBRATION AND STRUCTURES - THE ISO SCENE

Within the International Standards Organisation the generic aspects of vibration fall within the remit of Technical Committee (TC) 108 which has numerous sub-committees (SC's). Of particular relevance are those dealing with the measurement and evaluation of shock and vibration (SC2), human response to shock and vibration (SC4) and instrumentation (SC4). A Working Group of SC2 deals with the measurement and evaluation of shock and vibration in stationary structures. This WG3 produced ISO 4886 which is dual numbered as BS 7385 Part 1. ISO 4866 has an informative amendment awaiting circulation from Geneva describing the estimation of natural frequency of buildings such as may be called for in some procedures suggested in ISO 4866. Over the last four years the WG has been producing a standard for vibration measurement in underground rail tunnels which does not deal with the environmental issues or the response of nearby buildings so will not be considered further.

In the pipeline is another informative amendment which deals with soil-structure interaction; with particular reference to the factors which have to be considered if measurements have to be made outside a building on the ground. Professor Dolling has circulated a questionnaire seeking information on the ratio between vertical ppv measured on the ground surface and on a building foundation. Forty six velocities indicated a preferred value of about 0.6.

For three years a document originating in the USA aiming to establish guidelines on the range of vibrations of concern, has been worked upon. It started with a simple idea from David Siskind that it might be possible to gain international consensus for, on the one hand, the particle velocity measured at foundation level which could robustly be regarded as too small to worry about and on the other hand, the level which would indeed give the expert an uneasy sleep. David Siskind suggested that for cosmetic damage the true figures would be 5mm/s and 100mm/s.

Arising from discussions within this project an attempt was made to elicit expert opinion. The outcome of these enquiries has shown a wide distribution of that opinion (5 - 50mm/s) with fourteen responses giving a preferred levels set by for around 30-40 mm/s as a comfortable lower level for transient vibration in the frequency range 8-40Hz.

Another work item which is being rapidly progressed in France is a model quality plan for the measurement and reporting of vibration in structures. Following from this work there is also a proposal to reopen the problem of a calibration standard for velocity sensing systems.

Over the last ten years it has become evident that the detail of many national codes tended to over interpret the evidence indeed some widely used and authoritative standards were not supported by any transparent and robust data base. Standards are driven by the market which too often demands certitude where none can be given. Efforts to spread the data base over too many categories devalues the currency. There is a Say's Law in ppv - the lowest appearing in print is understandably but too often used to cover the posterior of the regulator.

These are issues broader than can be addressed here; they involve concepts of risk management and the role of experts. Of course it might be argued that the generally conservative regulators is the reason for the paucity of damage instances which can constrain the relationships used, but at what cost ?

CASE HISTORY STUDY (1986-1988)

- Graph prepared showing proportion of damage cases in the survey
- Supports general assumption that there is a greater risk of damage occurring above say 15 mm/sec ppv.
- Percentage values on the ordinate scale may be misleading because
  - (a) assumption of an unselective mechanism for gathering data does not apply - the data set has an inbuilt deliberate bias arising from the questionnaire
  - (b) sparsity of data above 15 mm/sec ppv. (only 10 damage cases), which is not readily apparent when a ratio is taken

Interesting trend only

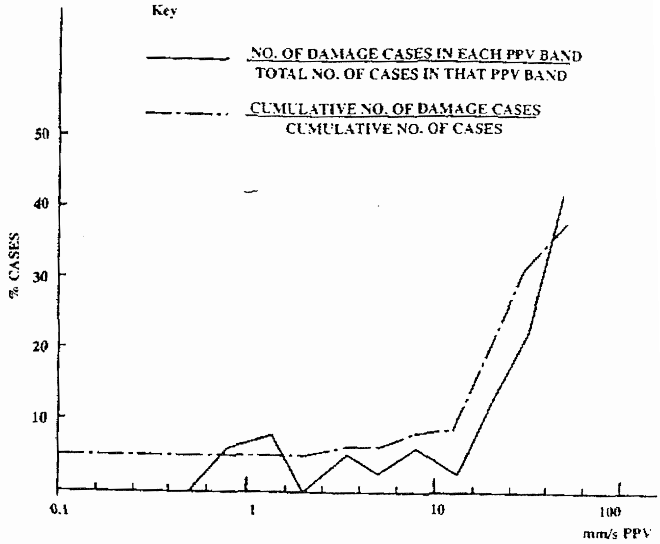


Figure 1: Proportion of Damage Cases in Survey

CASE DISTRIBUTION BY BUILDING TYPE

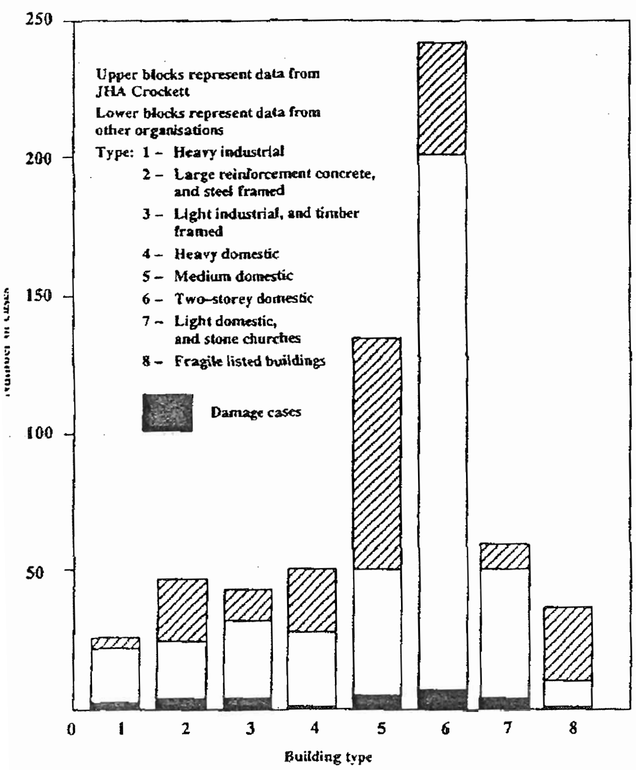
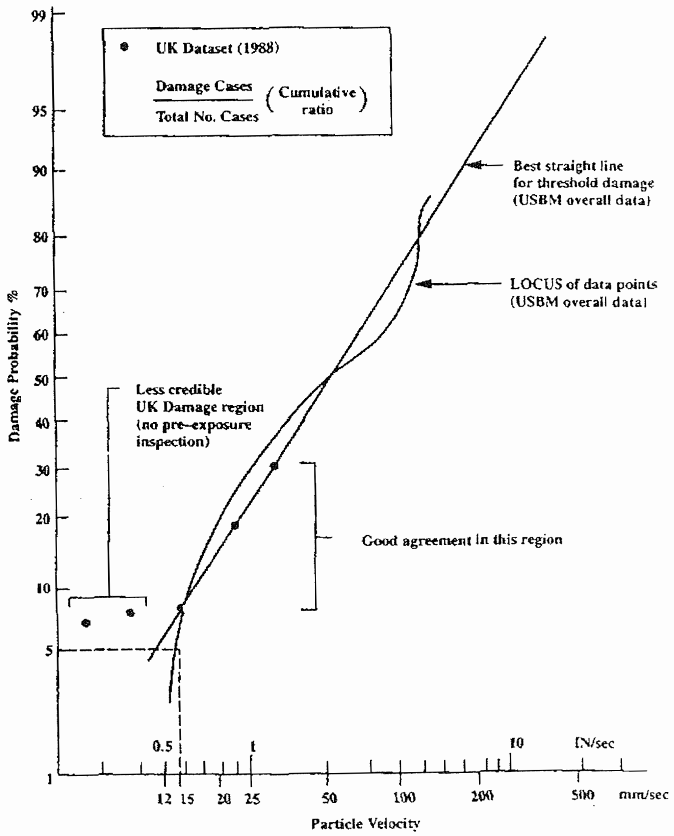


Figure 2: Number of Cases for each Building Type



Damage Probability Derived from Uncorrelated UK Data Compared with USBM Overall Data

Table 1 Transient Vibration Limits

Line	Type of Building	Peak component particle velocity (mm/s) in frequency range of predominant pulse	
1	Reinforced or framed structures Industrial or heavy commercial type buildings	50 at 4 Hz and above	
2	Unreinforced or light framed structures Residentail or light commercial type buildings	15 at 4 Hz increasing to 20 at 15 Hz	20 at 15 Hz increasing to 50 at 40 Hz and above

Notes:

1. Values applied in general at the base of the building
2. Below 4 Hz, a maximum displacement of 0.6mm (0–pk) should not be exceeded.
3. In the absence of a detailed engineering analysis which may permit higher levels to be used elsewhere on the building, the above values may be taken as a conservative guide.

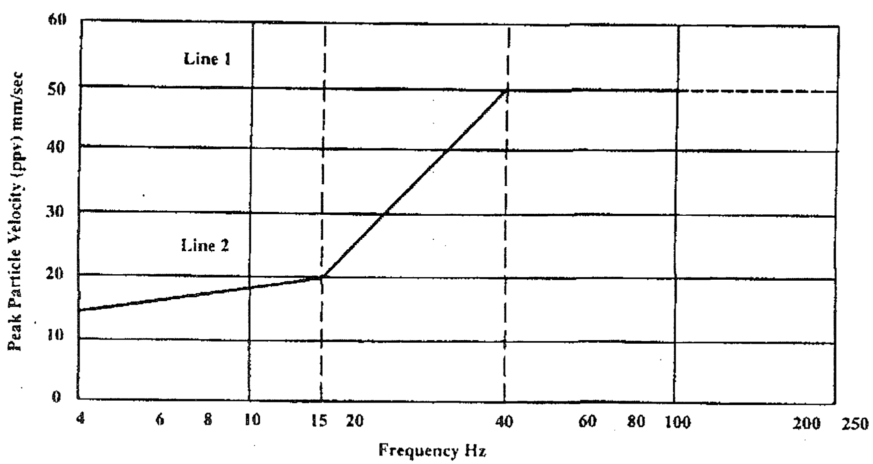


Figure 1: Transient vibration limits above which cosmetic damage can occur

BS7385: PART 2 (THIRD DRAFT – 18.9.92)

Table 2 Continuous Vibration Limits (Implied in Draft Standard)

Line	Type of Building	Peak component particle velocity (mm/s) in frequency range of predominant pulse	
1	Reinforced or framed structures Industrial or heavy commercial type buildings	25 at 4 Hz and above	
2	Unreinforced or light framed structures Residentail or light commercial type buildings	7.5 at 4 Hz increasing to 10 at 15 Hz	10 at 15 Hz increasing to 25 at 40 Hz and above

Notes:

1. Values applied in general at the base of the building
2. Below 4 Hz, a maximum displacement of 0.3mm (0–pk) should not be exceeded.
3. In the absence of a detailed engineering analysis which may permit higher levels to be used elsewhere on the building, the above values may be taken as a conservative guide.

BS7385: PART 2 (THIRD DRAFT – 18.9.92)

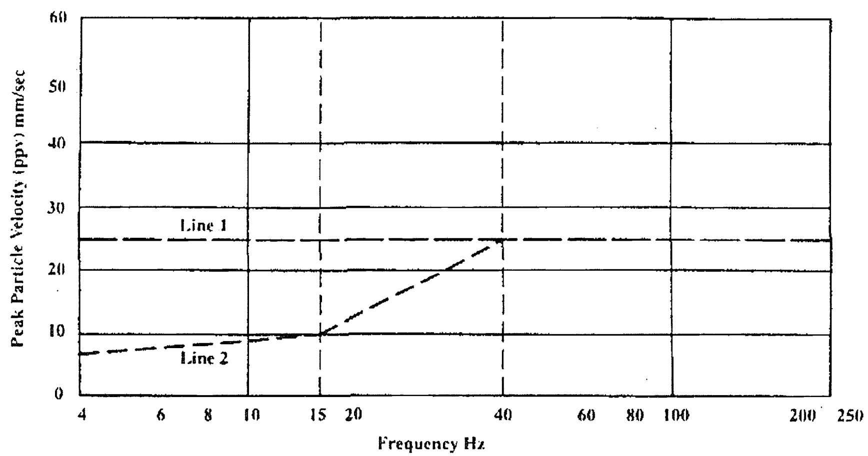


Figure 2: Continuous vibration limits above which cosmetic damage can occur (Implied in Draft Standard)

EUROPEAN PRE-STANDARDS (ENV)

The current Structural Eurocodes programme under the supervision of CEN/TC will result in 9 Eurocodes each comprising several parts produced as separate publications. A total of 59 publications is anticipated, of which 27 are being progressed actively at the time of the Davos conference. The remaining parts will be initiated from 1993 onwards.

Each part will first be available for purchase as European Pre-Standards (ENV) in various languages from the CEN members (national standards organizations).

The first ENV to be available in each Eurocode will be that covering general/common rules and the further parts covering supplementary rules etc will follow. The initial parts are programmed to be available as under.

Short Title	*Publication target as ENV*
EUROCODE 1 Part 1 Basis of Design	April 1994
EUROCODE 1 Part 2-1 Actions on Structures - general rules	January 1994
EUROCODE 2 Part 1-1 Concrete - general rules	Available since May 1992 (253 pages)
EUROCODE 3 Part 1-1 Steel - general rules	Available since September 1992 (approx 280 pages)
EUROCODE 4 Part 1-1 Composite - general rules	April 1993
EUROCODE 5 Part 1-1 Timber - common unified rules	October 1993
EUROCODE 6 Part 1-1 Masonry - general rules	May 1995
EUROCODE 7 Part 1 Geotechnics - common rules	June 1994
EUROCODE 8 Part 1-1 Seismic - general rules	April 1995
EUROCODE 9 Part 1-1 Aluminium - general rules	December 1996

SECED, The Society for Earthquake and Civil Engineering Dynamics is the British national section of the International and European Associations for Earthquake Engineering and is an affiliated society of the Institution of Civil Engineers. It is also sponsored by the Institution of Mechanical Engineers, the Institution of Structural Engineers, and the Geological Society. The Society is also closely associated with EEFIT, the UK Earthquake Engineering Field Investigation Team. The objective of the Society is to promote cooperation in the advancement of knowledge in the fields of earthquake engineering and civil engineering dynamics including blast, impact and other vibration problems.

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