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Croft Structural Engineers  
Clock Shop Mews  
Rear of 60 Saxon Road  
London SE25 5EH

T: 020 8684 4744  
E: [enquiries@croftse.co.uk](mailto:enquiries@croftse.co.uk)  
W: [www.croftse.co.uk](http://www.croftse.co.uk)

# Structural Monitoring Statement

24 Belsize Lane  
Hampstead  
London  
NW3 5AB

Jake Puddy

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## 1. Introduction

Basement works are intended to 24 Belsize Lane. The structural works for this require Party Wall Awards. This statement describes the procedures for the Principal Contractor to follow to observe any movement that may occur to the existing properties, and also describes mitigation measures to apply if necessary.

## 2. Risk Assessment

The purpose of this risk assessment is to consider the impact of the proposed works and how they impact the party wall. There are varying levels of inspection that can be undertaken and not all works, soil conditions and properties require the same level of protection. The highlighted are the monitoring levels required with the current proposal.

Monitoring Level Proposed	Type of Works.
<p><b>Monitoring 1</b></p> <ul style="list-style-type: none"><li>• Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works.</li></ul>	<p>Loft conversions, cross wall removals, insertion of padstones Survey of LUL and Network Rail tunnels. Mass concrete, reinforced and piled foundations to new build properties</p>
<p><b>Monitoring 2</b></p> <ul style="list-style-type: none"><li>• Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works.</li><li>• Visual inspection of existing party wall during the works.</li><li>• Inspection of the footing to ensure that the footings are stable and adequate.</li></ul>	<p>Removal of lateral stability and insertion of new stability frames Removal of main masonry load bearing walls. Underpinning works less than 1.2m deep</p>

<p><b>Monitoring 3</b></p> <ul style="list-style-type: none"><li>• Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works.</li><li>• Visual inspection of existing party wall during the works.</li><li>• Inspection of the footing to ensure that the footings are stable and adequate.</li><li>• Vertical monitoring movement by standard optical equipment</li></ul>	<p>Lowering of existing basement and cellars less than 2.50m Underpinning works less than 3.0m deep in clays Basements up to 2.0m deep in clays</p>
<p><b>Monitoring 4</b></p> <ul style="list-style-type: none"><li>• Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works.</li><li>• Visual inspection of existing party wall during the works.</li><li>• Inspection of the footing to ensure that the footings are stable and adequate.</li><li>• Vertical monitoring movement by standard optical equipment</li><li>• Lateral movement between walls by laser measurements</li></ul>	<p>New basements greater than 2.0m and shallower than 3.5m Deep in gravels or clays Underpinning works to Grade I listed building Piled retaining walls to 2m deep</p>

### 3. Scheme Details

This document has been prepared by Croft Structural Engineers Ltd. It covers the proposed construction of a new basement underneath the existing structure at 24 Belsize Lane

### Scope of Works

The works comprise:

- Visual Monitoring of the party wall
- Attachment of Tell tales or Demec Studs to accurately record movement of significant cracks.
- Attachment of levelling targets to monitor settlement.
- The monitoring of the above instrumentation is in accordance with Appendix A. The number and precise locations of instrumentation may change during the works; this shall be subject to agreement with the Principal Contractor (PC).
- All instruments are to be adequately protected against any damage from construction plant or private vehicles using clearly visible markings and suitable head protection e.g. manhole rings or similar. Any damaged instruments are to be immediately replaced or repaired at the contractors own cost.
- Reporting of all data in a manner easily understood by all interested parties.
- Co-ordination of these monitoring works with other site operations to ensure that all instruments can be read and can be reviewed against specified trigger values both during and post construction.
- Regular site meetings by the Principal Contractor (PC) and the Monitoring Surveyor (MS) to review the data and their implications.

- Review of data by Croft Structural Engineers

In addition, the PC will have responsibility for the following:

- Review of methods of working/operations to limit movements, and
- Implementation of any emergency remedial measures if deemed necessary by the results of the monitoring.

The Monitoring Surveyor shall allow for settlement and crack monitoring measures to be installed and monitored on various parts of the structure described in Table 1 as directed by the PC and Party Wall Surveyor (PWS) for the Client.

Item	Instrumentation Type
Party Wall Brickwork Settlement monitoring Crack monitoring	Levelling equipment & targets Visual inspection of cracking, Demec studs where necessary

Table 1: Instrumentation

## General

The site excavations and substructure works up to finished ground slab stage have the potential to cause vibration and ground movements in the vicinity of the site due to the following:

- a) Removal of any existing redundant foundations / obstructions;
- b) Installation of reinforced concrete retaining walls under the existing footings;
- c) Excavations within the site

The purpose of the monitoring is a check to confirm building movements are not excessive.

This specification is aimed at providing a strategy for monitoring of potential ground and building movements at the site.

This specification is intended to define a background level of monitoring. The PC may choose to carry out additional monitoring during critical operations. Monitoring that should be carried out is as follows:

- a) Visual inspection of the party wall and any pre-existing cracking
- b) Settlement of the party wall

All instruments are to be protected from interference and damage as part of these works.

Access to all instrumentation or monitoring points for reading shall be the responsibility of the Monitoring Surveyor (MS). The MS shall be in sole charge for ensuring that all instruments or monitoring points can be read at each visit and for reporting of the data in a form to be agreed with the PWS. He shall inform the PC if access is not available to certain instruments and the PC will, wherever possible, arrange for access. He shall immediately report to the PC any damage. The Monitoring Surveyor and the Principal Contractor will be responsible for ensuring that all the instruments that fall under their respective remits as specified are fully operational at all times and any defective or damaged instruments are immediately identified and replaced.

The PC shall be fully responsible for reviewing the monitoring data with the MS - before passing it on to Croft Structural Engineers - determining its accuracy and assessing whether immediate action is to be taken by him and/or other contractors on site to prevent damage to instrumentation or to ensure safety of the site and personnel. All work shall comply with the relevant legislation, regulations and manufacturer's instructions for installation and monitoring of instrumentation.

## Applicable Standards and References

The following British Standards and civil engineering industry references are applicable to the monitoring of ground movements related to activities on construction works sites:

1. BS 5228: Part 1: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 1.Code of practice for basic information and procedures for noise and vibration control, Second Edition, BSI 1999.
2. BS 5228: Part 2: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 2.Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance, Second Edition, BSI 1997.
3. BS 7385-1: 1990 (ISO 4866:1990) - Evaluation and measurement for vibration in buildings - Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings, First Edition, BSI 1990.
4. BS 7385-2: 1993 - Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration, First Edition, BSI 1999.
5. CIRIA SP 201 - Response of buildings to excavation-induced ground movements, CIRIA 2001.

## SPECIFICATION FOR INSTRUMENTATION

### General

The Monitoring Contractor is required to monitor, protect and reinstall instruments as described. The readings are to be recorded and reported. The following instruments are defined:

- a) Automatic level and targets: A device which allows the measurement of settlement in the vertical axis. To be installed by the MS.
- b) Tell-tales and 3 stud sets: A device which allows measurement of movement to be made in two axes perpendicular to each other. To be installed by the MS.

### Monitoring of existing cracks

The locations of tell-tales or Demec studs to monitor existing cracks shall be agreed with Croft Structural Engineers.

### Instrument Installation Records and Reports

Where instrumentation is to be installed or reinstalled, the Monitoring Surveyor, or the Principal Contractor, as applicable, shall make a complete record of the work. This should include the position and level of each instrument. The records shall include base readings and measurements

taken during each monitoring visit. Both tables and graphical outputs of these measurements shall be presented in a format to be agreed with the CM. The report shall include photographs of each type of instrumentation installed and clear scaled sections and plans of each instrument installed. This report shall also include the supplier's technical fact sheet on the type of instrument used and instructions on monitoring.

Two signed copies of the report shall be supplied to the PWS within one week of completion of site measurements for approval.

## Installation

All instruments shall be installed to the satisfaction of the PC. No loosening or disturbance of the instrument with use or time shall be acceptable. All instruments are to be clearly marked to avoid damage.

All setting out shall be undertaken by the Monitoring Surveyor or the Principal Contractor as may be applicable. The precise locations will be agreed by the PC prior to installation of the instrument.

The installations are to be managed and supervised by the Instrumentation Engineer or the Measurement Surveyor as may be applicable.

## Monitoring

The frequencies of monitoring for each Section of the Works are given in Appendix A.

The following accuracies/ tolerances shall be achieved:

Party Wall settlement	$\pm 1.75\text{mm}$
Crack monitoring	$\pm 0.75\text{mm}$

## REPORT OF RESULTS AND TRIGGER LEVELS

### General

Within 24 hours of taking the readings, the Monitoring Surveyor will submit a single page summary of the recorded movements. All readings shall be immediately reviewed by Croft Structural Engineers prior to reporting to the PWS.

Within one working day of taking the readings the Monitoring Contractor shall produce a full report (see below).

The following system of control shall be employed by the PC and appropriate contractors for each section of the works. The Trigger value, at which the appropriate action shall be taken, for each section, is given in Table 2, below.

The method of construction by use of sequential underpins limits the deflections in the party wall.

Between the trigger points, which are no greater than 2 m apart, there should be no more than:

Allowable movement to BS5950 for brittle finishes

$$\text{Vertical} = \text{Span} / 360 = 4000\text{mm} / 360 = 11.1\text{mm}$$

Croft proposes a tighter recommendation of Span / 500

$$= \text{Span} / 500 = 4000\text{mm} / 1000 = 4\text{mm}$$

Above Monitoring level 3 lateral movement is required to be measured and the figures should be

$$\text{Horizontal} = \text{Height} / 500 = 4000\text{mm} / 500 = 9\text{mm}$$

Croft proposes a tighter recommendation of

$$= \text{Height} / 750 = 4000\text{mm} / 1300 = 3\text{mm}$$

Due to the accuracy of the measuring instruments, the lowest trigger limit has been set to 3mm.



During works measurements are taken, these are compared with the limits set out below:

MOVEMENT		CATEGORY	ACTION
Vertical	Horizontal		
0mm-4mm	0-3mm	Green	No action required
4mm-6mm	3-6mm	AMBER	<p>Detailed review of Monitoring: Check studs are OK and have not moved. Ensure site staff have not moved studs. If studs have moved reposition.</p> <p>Relevel to ensure results are correct and tolerance is not a concern.</p> <p>Inform Party Wall surveyors of amber readings.</p> <p>Double the monitoring for 2 further readings. If stable revert back.</p> <p>Carry out a local structural review and inspection.</p> <p>Preparation for the implementation of remedial measures should be required.</p> <p>Double number of lateral props</p>
6mm-10mm	6-8mm		Implement remedial measures review method of working and ground conditions
>10mm	>8mm	RED	<p>Implement structural support as required;</p> <p>Cease works with the exception of necessary works for the safety and stability of the structure and personnel;</p> <p>Review monitoring data and implement revised method of works</p>

Table 2 – Movement limits between adjacent sets of Tell-tales or stud sets

Any movements which exceed the individual amber trigger levels for a monitoring measure given in Table 2 shall be immediately reported to the PWS, and a review of all of the current monitoring data for all monitoring measures must be implemented to determine the possible causes of the trigger level being exceeded. Monitoring of the affected location must be increased and the actions described above implemented. Assessment of exceeded trigger levels must not be carried out in isolation from an assessment of the entire monitoring regime as the monitoring measures are

inter-related. Where required, measures may be implemented or prepared as determined by the specific situation and combination of observed monitoring measurement data.

## Standard Reporting

1 No. electronic copy of the report in PDF format shall be submitted to the PWS.

The Monitoring Surveyor shall report whether the movements are within (or otherwise) the Trigger Levels indicated in Table 2. A summary of the extent of completion of any of the elements of works and any other significant events shall be given. These works shall be shown in the form of annotated plans (and sections) for each survey visit both local to the instrumentation and over a wider area. The associated changes to readings at each survey or monitoring point shall be then regulated to the construction activity so that the cause of any change, if it occurs, can be determined.

The Monitoring Surveyor shall also give details of any events on site which in his opinion could affect the validity of the results of any of the surveys.

The report shall contain as a minimum, for each survey visit the following information:

- a) The date and time of each reading;
- b) The weather on the day;
- c) The name of the person recording the data on site and the person analysing the readings together with their company affiliations;
- d) Any damage to the instrumentation or difficulties in reading;
- e) Tables comparing the latest reading with the last reading and the base reading and the changes between these recorded data;
- f) Graphs showing variations in crack width with time for the crack measuring gauges; and
- g) Construction activity as described. It is very important that each set of readings is associated with the extent of excavation and construction at that time. Readings shall be accompanied by information describing the extent of works at the time of readings. This shall be agreed with the PC.

Spread-sheet columns of numbers should be clearly labelled together with units. Numbers should not be reported to a greater accuracy than is appropriate. Graph axis should be linear and clearly labelled together with units. The axis scales are to be agreed with the PC before the start of monitoring and are to remain constant for the duration of the job unless agreed otherwise. The specified trigger values are also to be plotted on all graphs.

The reports are to include progress photographs of the works both general to the area of each instrument and globally to the main Works. In particular, these are to supplement annotated plans/sections described above. Wherever possible the global photographs are to be taken from approximately the same spot on each occasion. The locations of these points on site are to be Croft Structural Engineers drawing TW-30 Monitoring Plan.

## Erroneous Data

All data shall be checked for errors by the Monitoring Surveyor prior to submission. If a reading that appears to be erroneous (i.e. it shows a trend which is not supported by the surrounding instrumentation), he shall notify the PC immediately, resurvey the point in question and the neighbouring points and if the error is repeated, he shall attempt to identify the cause of the error. Both sets of readings shall be processed and submitted, together with the reasons for the errors and details of remedial works. If the error persists at subsequent survey visits, the Monitoring Surveyor shall agree with the PC how the data should be corrected. Correction could be achieved by correcting the readings subsequent to the error first being identified to a new base reading.

The Monitoring Surveyor shall rectify any faults found in or damage caused to the instrumentation system for the duration of the specified monitoring period, irrespective of cause, at his own cost.

## Trigger Values

Trigger values for maximum movements as listed in Table 2. If the movement exceeds these values then action may be required to limit further movement. The PC should be immediately advised of the movements in order to implement the necessary works.

It is important that all neighbouring points (not necessarily a single survey point) should be used in assessing the impact of any movements which exceed the trigger values, and that rechecks are carried out to ensure the data is not erroneous. A detailed record of all activities in the area of the survey point will also be required as specified elsewhere.

## Responsibility for Instrumentation

The Monitoring Surveyor shall be responsible for: managing the installation of the instruments or measuring points, reporting of the results in a format which is user friendly to all parties; and immediately reporting to all parties any damage. The Monitoring Surveyor shall be responsible for informing the PC of any movements which exceed the specified trigger values listed in Table 2 so that the PC can implement appropriate procedures. He shall immediately inform the PWS of any decisions taken.

## APPENDIX A MONITORING FREQUENCY

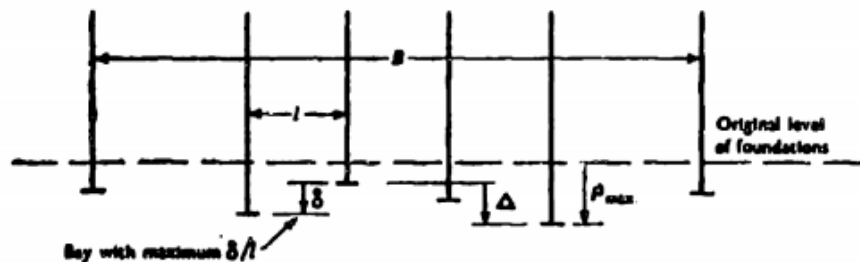
INSTRUMENT	FREQUENCY OF READING
Settlement monitoring and Monitoring existing cracks	<p><b><u>Pre-construction</u></b> Monitored once.</p> <p><b><u>During construction</u></b> Monitored after every pin is cast for first 4 no. pins to gauge effect of underpinning. If all is well, monitor after every other pin.</p> <p><b><u>Post construction works</u></b> Monitored once.</p>

## APPENDIX B

### An Analysis on allowable settlements of structures (Skempton and MacDonald (1956))

The most comprehensive studies linking self-weight settlements of buildings to structural damage were carried out in the 1950's by Skempton and MacDonald (1956) and Polshin and Tokar. These studies show that damage is most often caused by differential settlements rather than absolute settlements. More recently, similar empirical studies by Boscardin and Cording (1989) and Boone (1996) have linked structural damage to ground movements induced by excavations and tunnelling activities.

In 1955 Skempton and MacDonald identified the parameter  $\delta\rho/L$  as the fundamental element on which to judge maximum admissible settlements for structures. This criterion was later confirmed in the works of GRANT *et al.* [1975] and WALSH [1981]. Another important approach to the problem was that of BURLAND and WROTH [1974], based on the criterion of maximum tensile strains.



**Figure 2.1 – Diagram illustrating the definitions of maximum angular distortion,  $\delta/l$ , maximum settlement,  $\rho_{max}$ , and greatest differential settlement,  $\Delta$ , for a building with no tilt (Skempton and MacDonald, 1956).**

Figure 1: Diagram illustrating the definitions of maximum angular distortion,  $\delta/l$ , maximum settlement,  $\rho_{max}$ , and greatest differential settlement  $\Delta$ , for a building with no tilt (Skempton and MacDonald, 1956)

The differential settlement is defined as the greatest vertical distance between two points on the foundation of a structure that has settled, while the angular distortion, is the difference in elevation between two points, divided by the distance between those points.

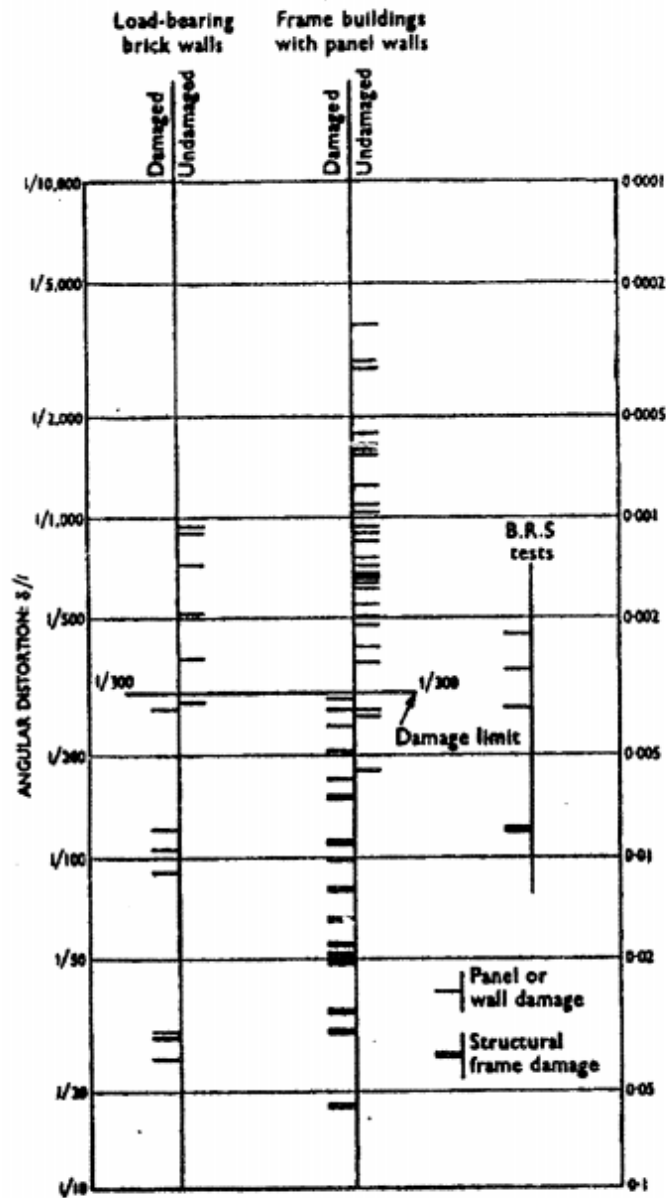
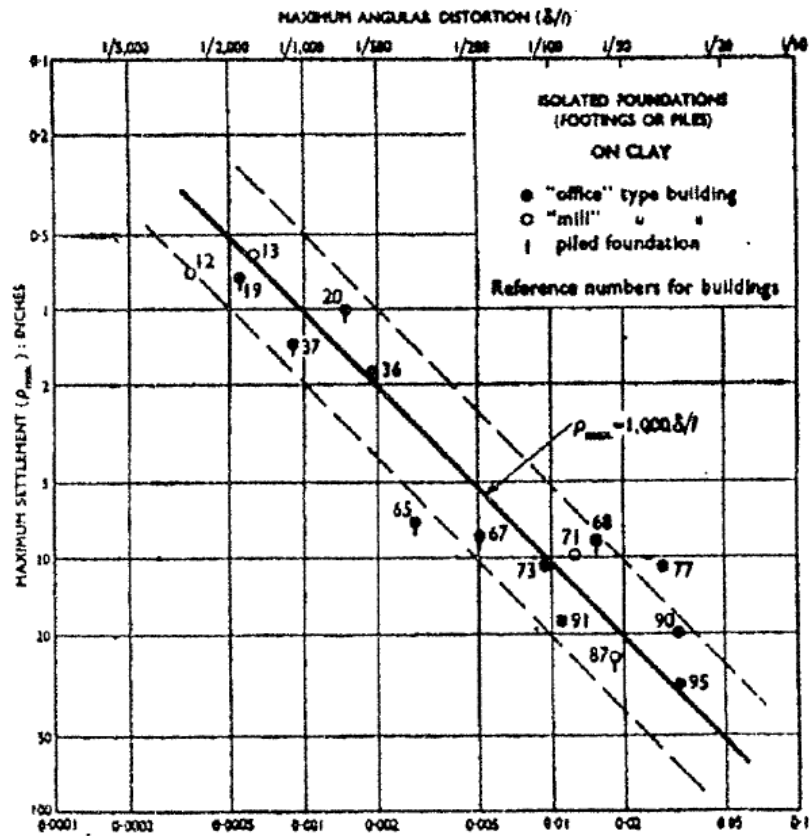
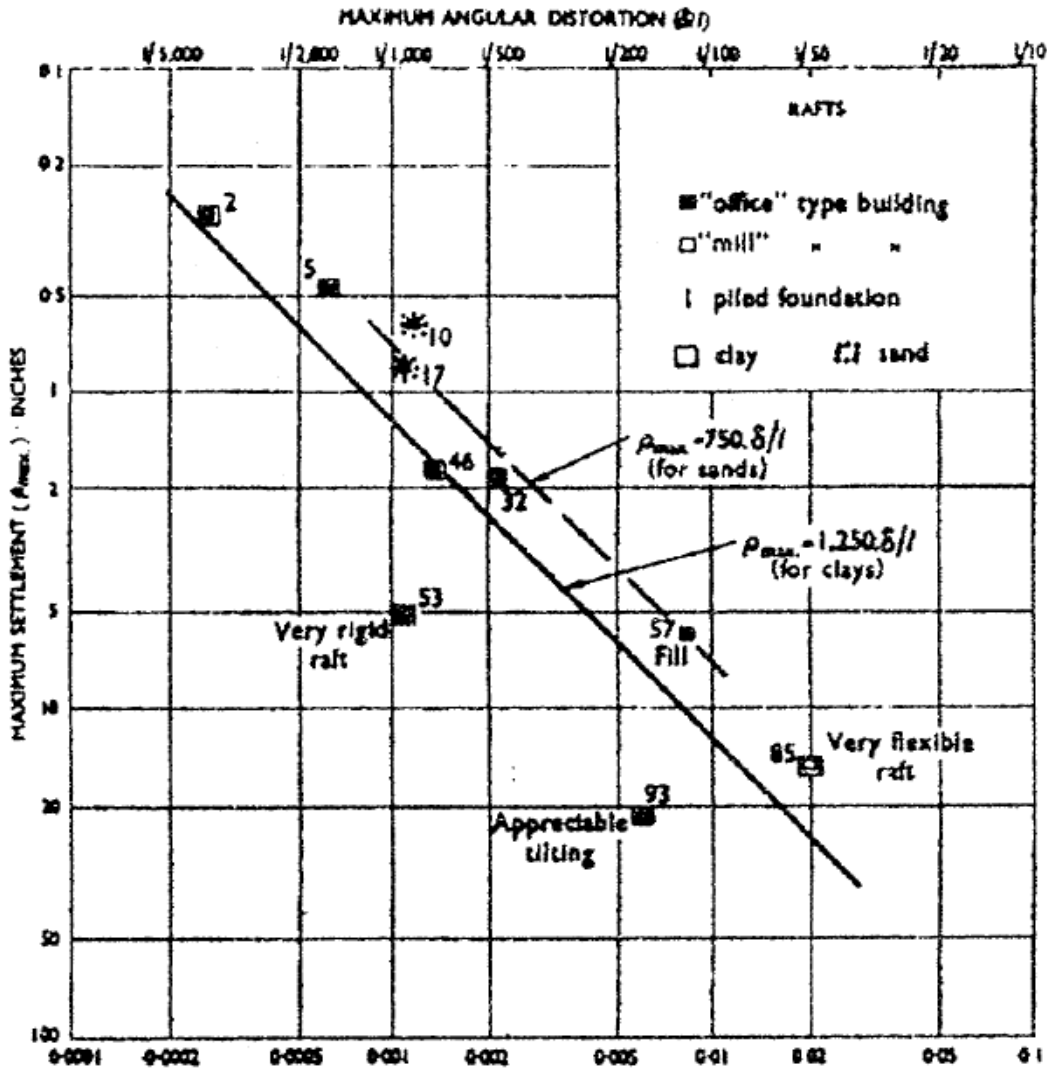


Figure 2: Skempton and MacDonald's analysis of field evidence of damage on traditional frame buildings and loadbearing brick walls

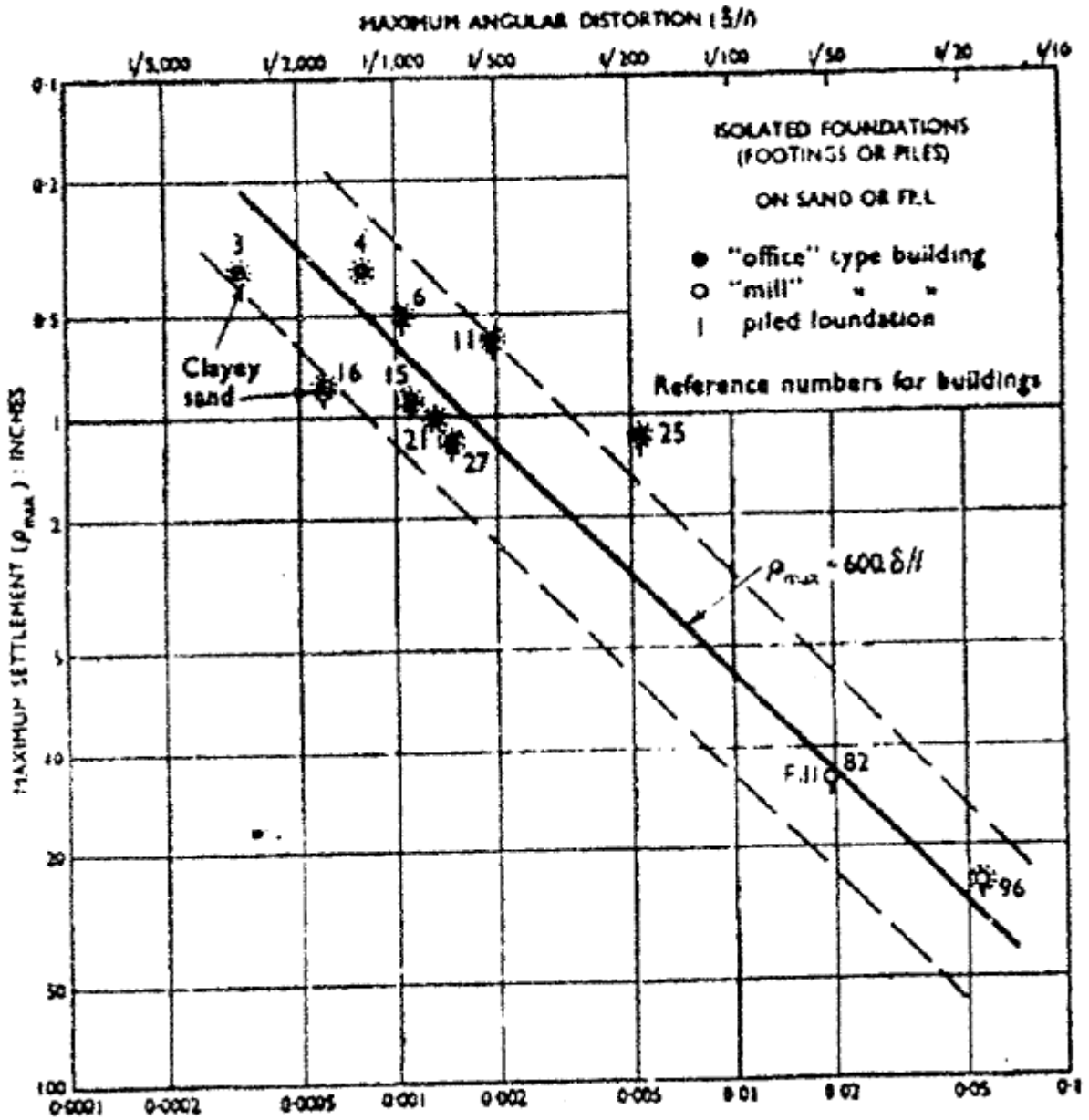
Data from Skempton and MacDonald's work suggest that the limiting value of angular distortion is 1/300. Angular distortion, greater than 1/300 produced visible cracking in the majority of buildings studied, regardless of whether it was a load bearing or a frame structure. As shown in the figure 2.

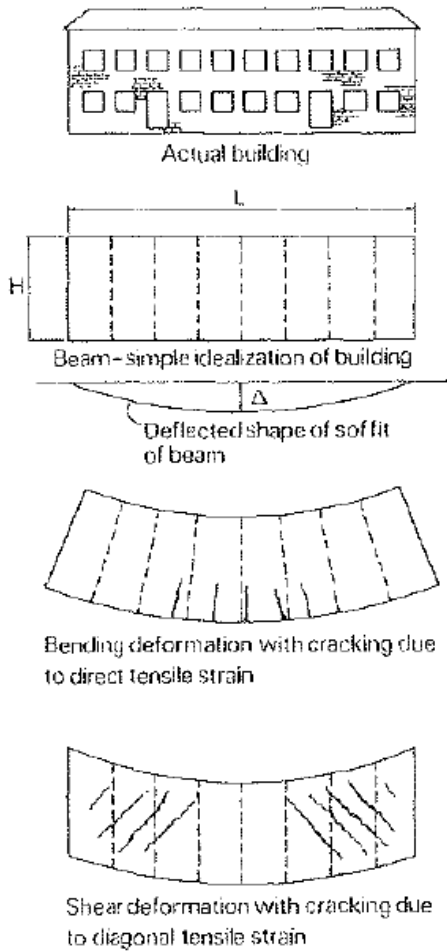
Other key findings by Skempton and MacDonald include limiting values of  $\delta/l$  for structure, and a relationship between maximum settlement,  $p_{max}$  and  $\delta/l$  for structures founded on sands and clays. The charts below show these relations for raft foundations and isolated footings.











**TABLE I**

<b>Angular distortion</b>	<b>Characteristic situation</b>
<b>1/300</b>	<b>Cracking of the panels in frame buildings of the traditional type, or of the walls in load-bearing wall buildings;</b>
<b>1/150</b>	<b>Structural damage to the stanchions and beams;</b>
<b>1/500</b>	<b>Design limit to avoid cracking;</b>
<b>1/1000</b>	<b>Design limit to avoid any settlement damage.</b>