

**PERIODIC STRUCTURAL INSPECTION
OF EXISTING BUILDINGS**

**GUIDELINES
FOR
STRUCTURAL ENGINEERS**

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GENERAL

1 Background

- 1.1 The periodic structural inspection of existing buildings was introduced with the promulgation of the Building Control Act in 1989. Requirements governing periodic structural inspection of existing buildings are stipulated in Part V of the Building Control Act and the Building Control (Inspection of Buildings) Regulations.
- 1.2 The periodic structural inspection applies to all existing buildings except:
- a) detached houses, semi-detached houses, terraced or linked houses which are used solely as places of residence; and
 - b) temporary buildings.
- 1.3 Periodic structural inspections are carried out based on the following frequency:
- a) every 10 years for buildings where at least 90% of its floor area is used solely for residential purposes; and
 - b) every 5 years for all other buildings.
- 1.4 The inspection consists of one or both of the following stages:
- Stage 1: visual inspection.
Stage 2: full structural investigation.

2 Qualifications and Expectations of Structural Engineers

- 2.1 There is a common misconception that a periodic structural inspection involves only a “visual” record of the observations during a brief tour of the building. Such misconception has to be corrected. The Building Control Act requires the visual inspection to be conducted by a structural engineer who must be a registered professional engineer in the civil or structural engineering discipline, rather than any other person. It is so because of the need for and importance of professional assessment and judgement in structural engineering during the visual inspection. Any other lesser assessment would provide little more than what a lay person could have observed from a casual inspection.
- 2.2 The structural engineer who is appointed by the building owner is therefore expected to carry out a comprehensive visual inspection that relies largely on his professional engineering assessment, judgement and advice. He shall exercise reasonable diligence and take active and personal interest in the planning and carrying out of the inspection of the building. A situation where he does not visit the building or totally delegates the inspection work to his

assistant or another person who is not a registered professional engineer in the civil and structural discipline is not an acceptable practice.

STAGE 1: VISUAL INSPECTION

3 Scope of Visual Inspection

- 3.1 Prior to the commencement of visual inspection, the structural engineer is to obtain a set of the building's structural layout plans from the building owner. The availability of the structural layout plan will help the structural engineer to:
- (a) understand the structural system and layout of the building;
 - (b) identify critical areas for inspection;
 - (c) identify the allowable imposed loads, in order to assess the usage and possibility of overloading; and
 - (d) verify if unauthorised addition or alteration works that affect the structure of the building have been carried out.
- 3.2 In general, the structural engineer is expected to carry out, with reasonable diligence, a visual inspection of:
- a) the condition of the structure of the building
 - to identify the types of structural defects
 - to identify any signs of structural distress and deformation
 - to identify any signs of material deterioration
 - b) the loading on the structure of the building
 - to identify any deviation from intended use, misuse and abuse which can result in overloading
 - c) any addition or alteration works affecting the structure of the building
 - to identify any addition or alteration works which can result in overloading or adverse effects on the structure.
- 3.3 If there are no signs of any structural deterioration or defects, the visual inspection should suffice and unless the structural engineer otherwise advises, no further action needs to be taken.
- 3.4 If, on the other hand, signs of significant structural deterioration or defects are present, the structural engineer should make a professional assessment of the deterioration or defect and recommend appropriate actions to be taken. Such actions may involve repair works or full structural investigation to parts or whole of the building.

4 Limitations of Visual Inspection

- 4.1 There could be some difficulties in the conduct of a visual inspection as some of the main structural elements in a building may have been covered up by architectural finishes. It is therefore important that professional judgement is exercised by the structural engineer to determine which areas that are covered up should be exposed for inspection. Reference to structural layout plans to determine the presence of critical structural elements would be crucial under such circumstances.
- 4.2 Notwithstanding these difficulties, an inspection by an experienced structural engineer who exercises reasonable diligence would not be entirely fruitless or futile.

5 Coverage of Visual Inspection

- 5.1 Structural engineers and building owners often question the expected coverage of a visual inspection. Owing to difficulties of access and other practical problems, it is sometimes not possible to inspect 100% of all areas in a building within a reasonable period of time.
- 5.2 The danger of prescribing any percentage lower than 100% is the possibility of doing the minimum, with the possible consequence of missing something important. It is therefore generally expected that the structural engineer carry out the visual inspection of all units or areas of a building. This is especially so for buildings where the imposed loading is high, usage varied or likely to be subjected to abuse or overloading, for example factories, industrial buildings, warehouses, shop houses, public assembly areas, etc.
- 5.3 For other buildings where the imposed loading is light, usage is fairly uniform and unlikely to be subjected to overloading (such as residential apartments, hotel rooms, general office areas), or if a reduced percentage of coverage is inevitable, the structural engineer must have the inspection sampling well distributed throughout the building and no significant defect or deterioration is found during his inspection of the sample. If the structural engineer foresees the possibility of abuse or overloading and detects signs of significant structural defects and possible deterioration, he should consider 100% inspection of the structure.
- 5.4 All parts of a building with special and critical structural elements or with no redundancy (e.g. transfer girders, slender columns, cantilever structures, long span structures, cable structures, connections and support conditions, etc.) must be inspected fully.

6 Repair Works arising from Visual Inspection

- 6.1 Major repairs and strengthening work, where necessary, shall be treated as building works. As such, procedures relevant to application for approval of plans, permit to carry out building works and supervision of building works shall apply.
- 6.2 Minor repairs can be treated as routine maintenance and will not require plan submissions or permit applications.

FORMAT OF VISUAL INSPECTION REPORT

7 Main Contents of Report

- 7.1 A report produced by the structural engineer is expected to be professional, clear and conclusive. A stereotype report written in a manner, which can be used for any building with minor changes to its title block, is defeating the purpose of the Act. On the other hand, a thick book consisting of mainly photographs with no engineering input may also not serve the purpose. The report should therefore reflect the fact that the structural engineer had carried out the inspection in a professional manner with reasonable diligence expected of him as a professional engineer. A well-prepared and professional report is demonstrated by the engineering views, assessment, judgement, conclusion and follow-up recommendations put forth based on the observations. Such a report is also useful for the owner as a maintenance record for any follow-up.
- 7.2 The following is a guide on the manner in which the Visual Inspection Report should be prepared. In addition, a checklist in Annex A is to be included in and as part of the inspection report.
- a) General Information of the Building**
- Name and address of the building
 - Number of storeys in each block of building
 - Description of main usage of the building
 - Maintenance history of the building, if known
- b) Structural System of the Building**
- Description of the structural forms, systems and materials used in different parts of the building e.g. reinforced concrete, prestressed concrete, steel, etc
 - Description of the soil condition and foundation system, if known

- Identification critical structures and structures without redundancies (eg. transfer girders, slender columns, cantilever structures, long span structures, cable structures, etc)
- c) Diary and Scope of the Visual Inspection**
- Dates of inspection for different parts of the buildings
 - Description of any areas not covered by the visual inspection, the reasons and an assessment of whether such areas are critical to overall structural integrity of the building.
- d) Survey of Loading on the Building Structure**
- Records of and comments on the observations on the loading conditions, indicating the usage at different parts of the building and identifying any misuse, abuse or deviation from intended use. Special attention to be paid to industrial buildings (eg. factories and warehouses).
 - State whether existing usage and loading condition is compatible with the intended purpose of the structure.
 - State whether any misuse, abuse or deviation from intended use has given rise to excessive loading which can adversely affect the building structure.
 - Recommendations on any remedial actions to be taken by the owners e.g. restricting the usage, relocating heavy machineries, further investigation on the adequacy of the structure.
 - Where there is deviation from its intended use resulting in overloading or supporting higher design imposed load as recommended in BS6399, the need for further design check on structural adequacy and display of allowable imposed loading signage shall be recommended in the inspection report.
- e) Survey of Addition or Alteration Works to Building Structure**
- Records of and comments on the findings of any addition and alteration works to the building structure. Such information can be obtained by visual inspection, engineering judgement, interviewing the management corporation, owners and users, and checking the drawings if available to the engineer.
 - State whether any addition and alteration works have given rise to excessive loading or other adverse effects on the building structure.
 - Recommendations on any remedial actions to be taken by the owners e.g. the need for the removal of the addition and alteration works.
- f) Survey of Signs of Structural Defects, Damages, Distress, Deformation or Deterioration**
- Records of observations of any signs of structural defects, damages, distress, deformation or deterioration e.g. cracks, excessive deflection,

connection failure, instability, floor settlement, foundation settlement, tilt, spalling concrete, corrosion of steel, termite infestation, dry & wet rot timber, etc. This could entail judicious removal of plaster or architectural finishes to establish the underlying structural condition. The seriousness of any structural defects should be assessed.

- Comments on the extent, possible causes and assessment of the seriousness of these identified problems.
- Assess whether the identified problems are:
 - Defects of no structural significance
 - Defects requiring remedial action and/or monitoring
 - Suspected defects of structural significance requiring full structural investigation and immediate action
- Recommendations on remedial actions and/or monitoring necessary to ensure the structural stability and integrity of the building.
- Where there are signs of termite attack on timber structures the engineer shall recommend the owner to carry out inspection and treatment by an anti-termite specialist and obtain the certificate of termite treatment accordingly.
- If there are signs of significant structural problems, the engineer shall make recommendations for a full structural investigation to be carried out without further delay.

g) Survey of exposure to aggressive environment

- Presence of column(s) immersed in water (eg. ground floor water tank, sea water, lakes, etc)
- Presence of aggressive chemical which may accelerate the deterioration of structural elements, particularly in industrial buildings.

h) Survey of retaining walls and slope protection structures (eg. soil nails, ground anchors, shotcrete slope)

- Evidence of wall movement, inadequate surface drainage, unintended imposed loading behind wall, corrosion of anchor blockhead, spalling of shotcrete protection, tension cracks, presence of big trees nearby etc.

i) Survey of safety barriers (eg. parapets and railings)

- Signs of corrosion, excessive deflection, spalling, cracks, etc observed on safety barriers particularly those in buildings where large crowds are expected (eg. shopping malls, institutional buildings, sport halls, stadiums, theatres, etc)

j) Other Surveys or Checks Carried Out

- Presence of heavy suspended fixtures in crowded locations, such as heavy false ceilings over high human-traffic areas like food courts, lobbies etc.

- Records of and comments on any known maintenance problems and previous rectification carried out on the building structure. Useful plans, sketches, photographs and tabulations could also be included to illustrate the findings of the inspection;

k) Conclusions

- Conclusions on the structural condition shall include conclusions on loading conditions; addition and alteration works; structural defects, damage, distress, deformation, deterioration; and overall structural integrity and stability.

l) Sketches, Plans and Photographs

- All sketches, plans and photographs should have proper titles, explanations and cross-references to the main body of the report.
- Although photographs are often used by structural engineers as a record of their inspections, the entire collection of photographs should not be submitted indiscriminately, e.g. photographs of non-structural elements with no defects.

m) Structural Engineer’s Endorsement and Standard Certification

- The report shall be signed and endorsed on the first and last page by the Structural Engineer appointed to carry out the inspection as follows.

Standard Certification by the Structural Engineer for Periodic Inspection of Buildings	
In accordance with Section 28(6) of the Building Control Act (the “Act”) and Regulations 4 and 5 of The Building Control (Inspection of Buildings) Regulations (the “Regulations”), I, _____, the Structural Engineer appointed by the building owner under section 28(3) of the Act have personally conducted an inspection of the condition and structure of the building and hereby submit the report of the results of my inspection. I certify that the inspection was carried out and the report was prepared by me in accordance with the provisions of the Act and the Regulations.	
_____ Structural Engineer For Periodic Inspection of Buildings (Signature and Stamp)	_____ Date

- Depending on the results of the visual inspection, the Structural Engineer shall submit the Visual Inspection Certification (Form SF_ESID_SIS/SF-D3) as appropriate.

STAGE 2: FULL STRUCTURAL INVESTIGATION

8 General

- 8.1 On the recommendation of the structural engineer who carries out the visual inspection, BCA may grant approval for a full structural investigation to be carried out.
- 8.2 If the structural deficiencies are of a localised nature, the structural engineer may recommend a full structural investigation for that area in the first instance. The scope and extent of the investigation should be clearly defined and subject to the approval of BCA. The outcome of this investigation may lead to a full structural investigation for the whole building.
- 8.3 The owner may engage a different structural engineer to carry out the stage 2 inspection and should inform BCA of the appointment.

9 Scope of Full Structural Investigation

- 9.1 The scope of the full structural investigation includes the following:
- (a) obtaining information relating to the design, construction, maintenance and history of the building;
 - (b) assessing the structural adequacy of the building by checking the structural plans and calculations and reconstructing the structural plans if they are not available;
 - (c) carrying out tests on the materials used and structural elements of the building;
 - (d) carrying out load test on parts of the building if necessary;
 - (e) recommending appropriate safety precautionary and remedial measures to restore the structural stability and integrity of the building structure.

ANNEX A – CHECKLIST¹ FOR PERIODIC STRUCTURAL INSPECTION OF EXISTING BUILDING AT

<Building Address>

I declare that I have addressed in my visual inspection report all the checklist items as ticked² below.

- 1. Structural plans and details.
 - a) Reference to structural layout plans
 - b) Description of foundation system
 - c) Description of structural system (including storey height)
 - d) Any flat slab system (to state location)

- 2. Presence of critical structures and structures without redundancies
(eg. transfer girders, small/ narrow/ slender columns³, cantilever structures, long span structures, cable structures, timber structures, etc)

- 3. Loading:
 - a) Compatibility of existing usage with the design loading
 - b) Deviation from intended use or supporting higher design imposed load as recommended in BS 6399 (to recommend design check by a PE and display of signage for allowable imposed loading)
 - c) Signs of overloading (to show affected locations on plan)
 - d) Recommended remedial actions to be taken

- 4. Addition and Alteration works (A&A):
 - a) Presence of A&A (to show locations on plan)
 - b) Impact of A&A on the building structure

- 5. Signs of structural defects and deterioration:
 - a) Building tilt/ settlement
 - b) Structural deformation
 - c) Major structural defects (e.g. structural cracks, decayed timber member)

¹ This checklist is to be included in the inspection report.

² All checklist items are to be ticked and addressed in inspection report.

³ 'Supplementary Checklist for Critical Columns in Residential Buildings built before 1 Jan 1989' to be included where applicable

- d) Minor structural defects
- e) Non-structural defects
- f) Recommended remedial actions to be taken

- 6. Termite Attack:
 - a) Need for inspection by anti-termite specialist
 - b) Need for termite treatment by anti-termite specialist

- 7. Exposure to aggressive environment:
 - a) Column immersed in water (eg. ground floor water tank, sea water, lakes, etc)
 - b) Aggressive chemical which may accelerate the deterioration of structural elements, particularly in industrial buildings

- 8. Retaining walls and slope protection structures:
 - a) Defects of retaining wall and other slope protection structures (e.g. cracks, tilt, displacement, etc.)
 - b) Signs of undesirable condition surrounding retaining wall (e.g. tension cracks in soil, weephole chokage, presence of big trees nearby, inadequate surface drainage etc.)

- 9. Safety Barriers (i.e. parapets & railings):
 - a) Any defects
 - b) Any continuous handrail for full glass barriers

- 10. Record of previous strengthening works done

- 11. Standard Certification on first and last page of report

Structural Engineer
For Periodic Inspection of Buildings
(Signature and Stamp)

Date

ANNEX B - SUPPLEMENTARY CHECKLIST⁴ FOR CRITICAL COLUMNS IN RESIDENTIAL BUILDING(S) BUILT BEFORE 1 JAN 1989

I declare that I have addressed in my visual inspection report all the checklist items as ticked⁵ below.

1. Presence of Critical Columns:

- a) Design concrete grade 20
- b) Small-size, narrow, or slender columns⁶
- c) Columns subjected to bi-axial bending or bending about minor axis
- d) Columns unbraced along minor axis
- e) Void deck used as carpark

2. Signs of structural defects and deterioration:

- a) Spalling, cracks, or deformation
- b) Signs of damage by external force (eg. vehicular impact)
- c) Signs of differential settlement

3. Recommendations:

- a) Need for full structural investigation
- b) Need for crash barrier around void deck columns

Structural Engineer
For Periodic Inspection of Buildings
(Signature and Stamp)

Date

⁴ This supplementary checklist is to be used together with 'Annex A - Checklist for Periodic Structural Inspection of Existing Building' and submitted with the inspection report.

⁵ All checklist items are to be ticked and addressed in inspection report.

⁶ As a guide, small size or narrow columns are defined as having minimum width less than/ equal to 300mm

EXPLANATORY NOTES TO SUPPLEMENTARY CHECKLIST

1. Structural engineers are to pay special attention to the inspection of small-size, narrow or slender RC columns in void deck of residential buildings built before 1989 and using grade 20 concrete. For such structural elements, lack of maintenance, natural deterioration, accuracy of rebar placement, support settlement, or accidental impact force (eg. from vehicles in void deck carparks) could significantly affect the load capacity.
2. During the inspection of such critical structures, structural engineers are to be thorough in identifying early signs of deterioration/ distress and seriously consider recommending full structural investigation in order to ascertain the structural integrity of the columns as well as the need for strengthening or protection.