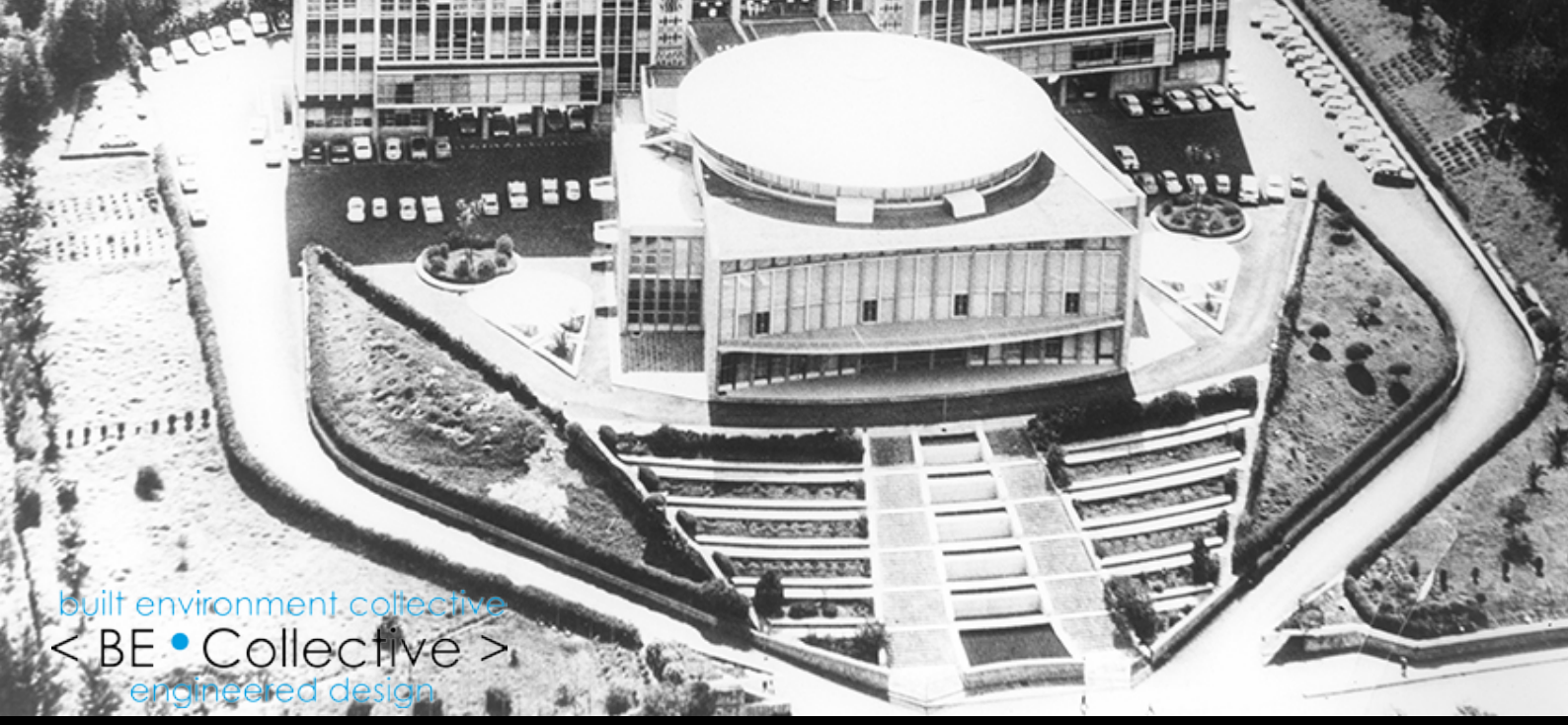
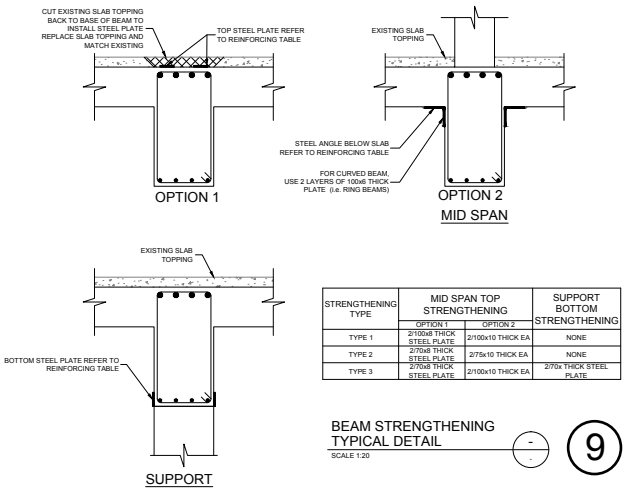


Africa Hall - Rehabilitation & Hertiage Preservation Detailed Design for the United Nations

Project Profile



STRENGTHENING TYPE	MID SPAN TOP STRENGTHENING		SUPPORT BOTTOM STRENGTHENING
	OPTION 1	OPTION 2	
TYPE 1	2/100x8 THICK STEEL PLATE	2/100x10 THICK EA	NONE
TYPE 2	2/70x8 THICK STEEL PLATE	2/75x10 THICK EA	NONE
TYPE 3	2/70x8 THICK STEEL PLATE	2/100x10 THICK EA	2/70x THICK STEEL PLATE

BEAM STRENGTHENING TYPICAL DETAIL
SCALE 1:20
9

Africa Hall is one of Ethiopia's historical Landmarks.

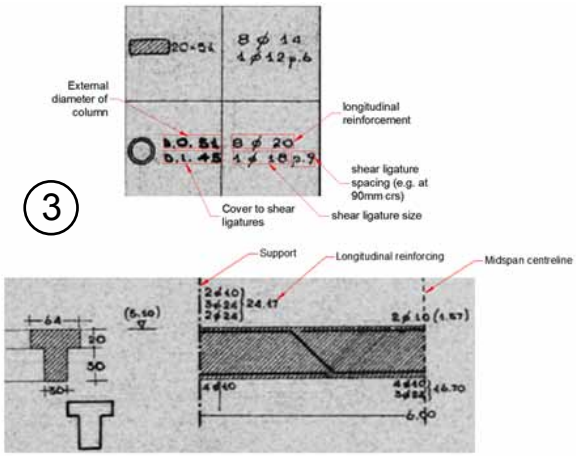
The building serves as the headquarters of the United Nations Economic Commission for Africa (UNECA).

Designed by architect Arturo Mezzedimi, the building was constructed from 1959 to 1961 and is recognised as one of the most significant buildings throughout all African Nations.

This heritage building housed the first summit of the African Union.

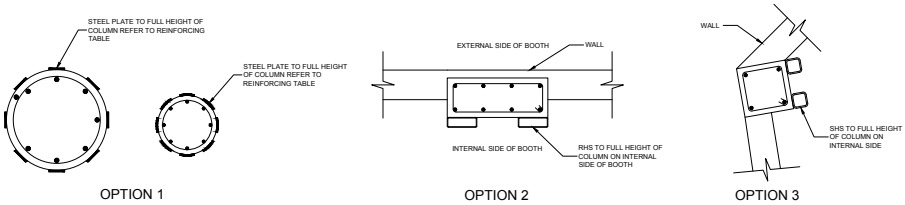
The international detailed design tender for remediation and heritage preservation was won by a team compiled by the small Australian engineering consultancy - Built Environment Collective who provided structural services.

BE Collective is Based in Brisbane, Australia... some 12866kms from Addis Ababa.

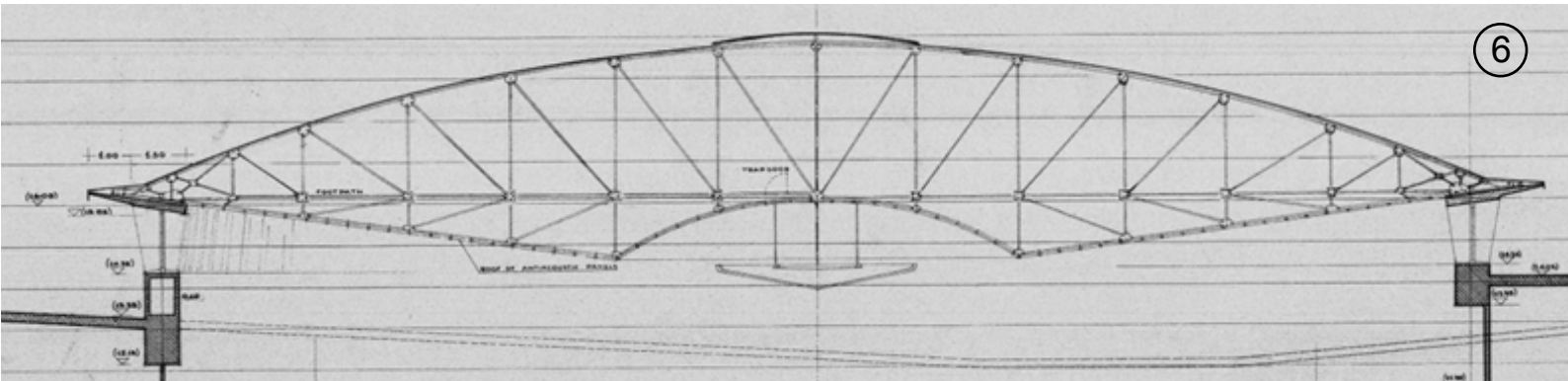


STRENGTHENING REQUIRED		
OPTION 1	OPTION 2	OPTION 3
8/70x8 THICK STEEL PLATE	2/ 150x50x3.0 RHS	2/ 75x3.0 SHS

NOTE: REFER TO DWGS S110,S111,S112



COLUMN STRENGTHENING TYPICAL DETAIL
SCALE 1:20
8



EXECUTIVE SUMMARY

Africa Hall is an historic heritage building in Addis Ababa which serves as the headquarters of the United Nations Economic Commission for Africa (UNECA). Designed by architect Arturo Mezzedimi, the building was constructed from 1959 to 1961 and is recognised as one of the most significant buildings throughout all African Nations. The design tender for remediation and heritage preservation of the UNECA Africa Hall Building was won by the project team instigated by Australian engineering firm Built Environment Collective (BE Collective). The commission consisted of Concept Design Reporting to inform project feasibility - providing recommendations and documentation for the required alterations and additions to preserve and update the building in terms of structural integrity, functionality and sustainability.

Creativity and innovation were necessitated and evidenced by delivering design outcomes for a heritage project some 12866 kms from the BE Collective Brisbane office, in a foreign country which has limited access to experienced contractors or high-tech materials. Sustainability in design was achieved by facilitating the 're-lifing' of a heritage building and supporting sustainability initiatives.

Structural remediation and building addition solutions were assessed and vetted against key performance criteria including cost, heritage preservation, special functionality and local contractor experience and materials availability.

Project excellence was achieved by providing comprehensive high quality documentation to the United Nations within a significantly short timeframe (March to May 2014). Feedback from the UNECA indicated that the structural analysis and documentation provided by BE Collective was considered extremely comprehensive.

1. PROJECT INTRODUCTION

Africa Hall is one of Ethiopia's historic Landmarks and serves as the headquarters of the United Nations Economic Commission for Africa (UNECA). Construction of the building started in 1959 and was completed and officially inaugurated by Emperor Haile Selassie of Ethiopia on 1961. This heritage listed building housed the first summit of the African Union (initially the Organization of African Unity), and has hosted other significant meetings which have shaped the recent history of the African nations. The structural system comprises a 4-storey reinforced concrete circular sway-frame above ground (also known as the Rotunda), and a braced-frame structure at basement level. The building is now more than 50-years old, and minimal structural repair/remediation has been undertaken during its design-life. The building use currently comprises basement storage, retail shops and café at the ground 'Rotunda'/ mezzanine levels, plus the Plenary Hall, circulation and meeting spaces on the first and second floor levels.

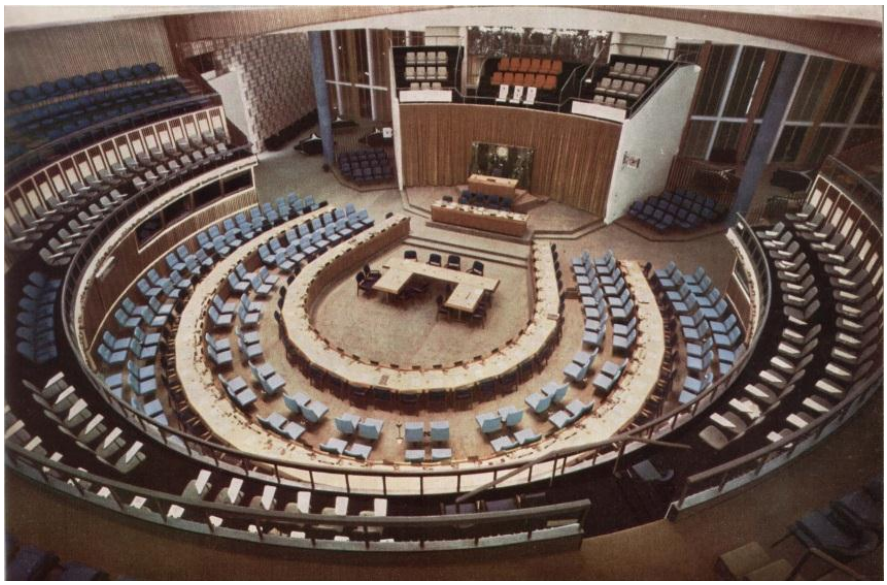


Figure 1 - Plenary Hall (image from Africa Hall publication by the Imperial Ethiopian Government)

2. SCOPE

The detailed design tender for the first stage of the renovation and heritage preservation of the UNECA Africa Hall building was completed in May 2014 by the project team initiated by Australian engineering consultancy Built Environment Collective (BE Collective). BE Collective invited heritage architects Conrad Gargett (formally Conrad Gargett Riddel Anchor Mortlock Woolley) to lead the international project team, which includes Ethiopian sub-consultants GT Consulting Engineers and San-Mech.

BE Collective produced a Concept Design Report as deliverable for the first stage commission - providing recommendations and documentation detailing the required alterations and additions in relation to structural integrity, efficiency and sustainability.

3. STRUCTURAL CONDITION ASSESSMENT

BE Collective scope included a visual structural condition survey which was undertaken by Managing Director John Tuxworth (MIStructE) in March 2014. John has undertaken forensic investigation and analysis across an international engineering career of some 20 years. The purpose of the visual assessment was to investigate external and internal building condition from a structural durability perspective, and to confirm 'as-constructed' structural framing and detailing.

Durability defects were identified throughout the concrete structure as would be expected due to initial build characteristics and building age, being predominately categorised as minor concrete cracking to moderate spalling. It was also identified that the recent addition of a mezzanine floor had resulted in significant cracking, slab deflection, and plastic elongation of reinforcing steel at areas of the suspended ground floor. These defects were catalogued for later analysis as part of our commissioned scope. Appropriate remediation techniques were proposed with consideration to cost, local contractor experience and material availability.

4. STRUCTURAL INTEGRITY

4.1 ANALYSIS

Relevant Ethiopian design standards are not limit-state and have not been updated since 1995. Building analysis was undertaken referencing current international standards (both Eurocode and Australian). Structural assessment, and analysis as appropriate, was undertaken for major structural elements throughout the building - including reinforced concrete columns, beams, slabs and foundations, as well as steel roof members. Several structural parameters were not able to be clearly interpreted from ammonia and 'blue' printed record copies of the 1959 'As-Built' structural drawings, and thus assumptions were adopted relating to reinforcing details (as shown in Figure 3 on entry cover page) and concrete strength (20MPa to account for uncertainties due to original construction quality). Recommendations of specialist testing were documented to validate design assumptions for consideration in future works.

The majority of elements within the complex structure were able to be assessed using 2-D analysis, in order to meet quick turnaround requirements. The two main analysis software utilised for the super structure were S-Frame and Tedds (internationally prevalent software by CSC).

Fire resistance of structural elements was also assessed to check compliance with current standards. Most elements did not meet the required FRL of present day standards and thus remediation solutions were investigated and recommended, such as the thickening of floor slabs, the use of fyre-check style cladding, and fire-engineered sprinkler options.

4.2 FINDINGS

Columns were evaluated for ultimate limit-state vertical and lateral design loads (including seismic forces). With incomplete record drawings, several assumptions based on current international design standards and known local construction practices were adopted. Analysis indicated that 28 of the ground floor columns and 14 first floor columns fail to accommodate ultimate limit state

loads as illustrated in Figure 2. In addition, the majority of the columns failed to meet the minimum steel reinforcing detailing requirements required by current international standards.

Beams were evaluated with respect to ultimate limit-state vertical and lateral design loads. It was identified that 15 beams had insufficient reinforcing steel to satisfy current international standards relating to seismic detailing.

Ground, first, and second floor slabs were assessed and analysed. Continuity of flexural reinforcement proved to be critical with respect to ultimate limit state design forces. Since record drawings were incomplete and difficult to interpret, it was recommended that further investigation be commissioned to verify the actual slab reinforcement detailing.

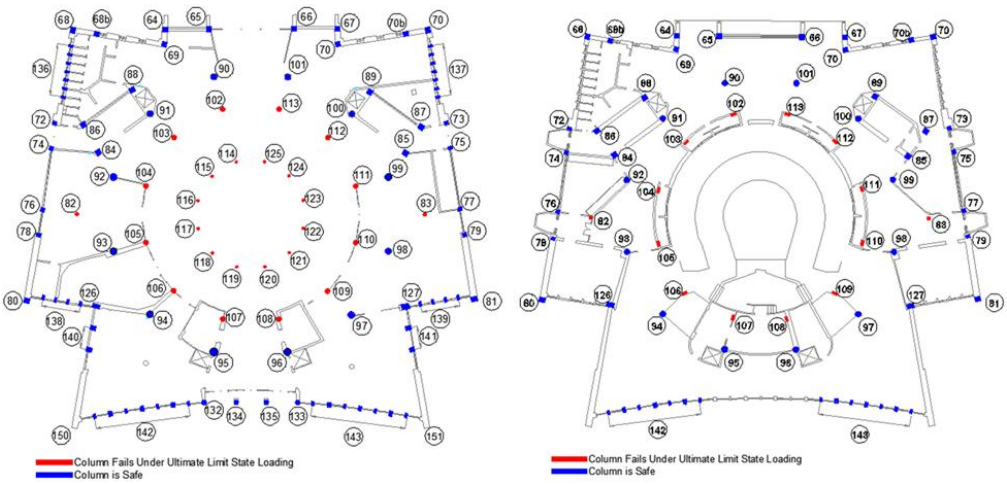


Figure 2 – Columns: Structural Design Assessment

The majority of slab elements fail to meet international standards with respect to recommended deflection criteria, and also with respect to dynamic vibration.

A recent addition to the building comprised a steel-framed mezzanine floor. Columns to the mezzanine were supported directly on the suspended ground floor with no additional strengthening. Additional loading of the suspended slab resulted in significant cracking and plastic deformation of the steel reinforcing. In addition, it was determined that steel beam members supporting the mezzanine floor were undersized with respect to imposed actions appropriate for where people may congregate. Several remediation techniques were investigated, however, considering the heritage intent, strengthening costs, and fire proofing requirements, it was identified that the most appropriate approach would be to remove the mezzanine floor and also reconstruct the failed sections of ground floor slab.

The roof system of the Africa Hall building consists of cylindrically arranged trusses which span up to 34m. Refer to Figure 3 and cover-page Figure 6 (1959 "As-Built" Drawings extract). Analysis of 'as-constructed' sections sizes and connections indicate adequacy with respect to ultimate actions including seismic and wind loadings.

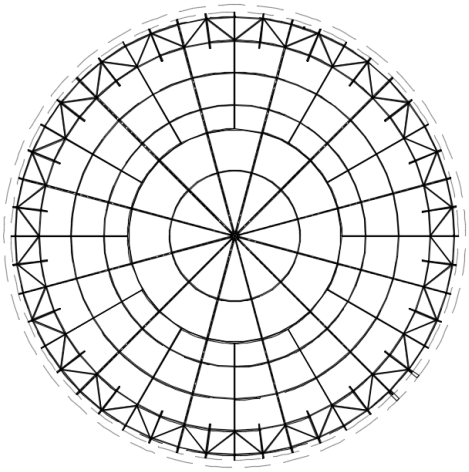


Figure 3 - Roof Truss Structure

5. STRUCTURAL CONCEPTS

5.1 STRENGTHENING

Several strengthening options were investigated to address issues identified in the structural review of the UNECA Africa Hall building. An options-based approach was used to provide UNECA full flexibility as to extent of remediation, and the ability to assess overall costs along with the visual and spacial impacts. Options included the use of Carbon Fibre Reinforced Polymer (CFRP) strengthening, the addition of steel plate sections to the perimeter of structural elements, and/or the bonding of reinforced concrete sleeves about structural members.

Although CFRP is a common practice low-profile strengthening option available in many countries, this option was considered too expensive and too much of a risk given the lack of materials and local contractor experience within the region. Another option investigated was to wrap deficient structural elements within a reinforced concrete sleeve to enhance structural capacity, however this was perceived to create issues relating to spatial planning and end-use. Considering all factors involved the addition of steel plate sections to the perimeter of columns and beams was deemed to be the favoured strengthening approach.

Documentation extracts of our proposed strengthening to columns, beams and a slab is provided in Figures 8, 9 and 4 respectively (refer to entry cover page for Figures 8 & 9).

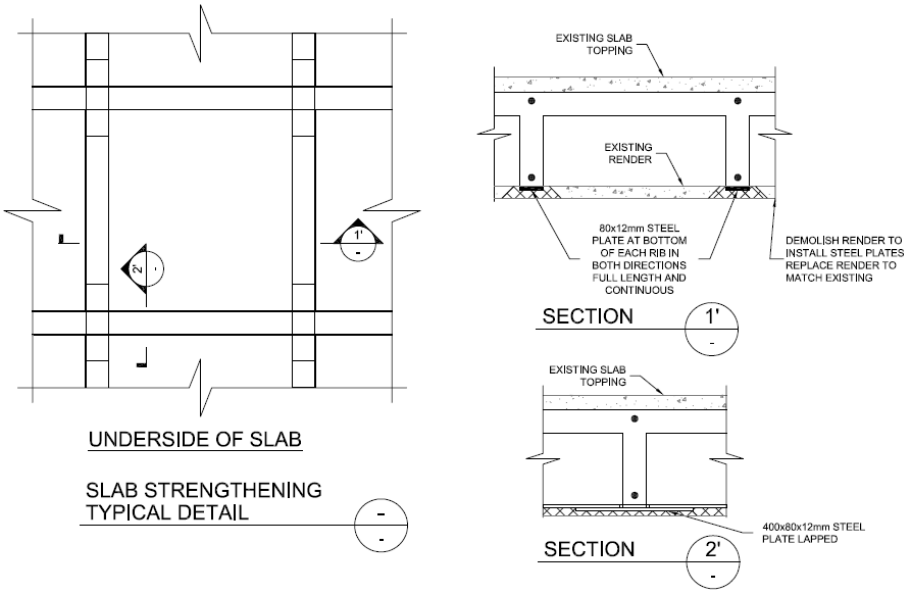


Figure 4 - Slab Strengthening Documentation Extract

5.2 PLANT DECK STRUCTURAL ADDITION

Part of the proposed refurbishment works for Africa Hall included addition of a new floor, to be constructed on top of the 34m level 1 link bridge, in order to provide state-of-the-art audio-visual facilities and plant deck for new mechanical ventilation. Our challenge was to minimize additional load to existing link bridge, and to minimise loading of other existing structure. A long-span truss structure was detailed to span independently between the two adjacent buildings.

The proposed truss structure comprises T-Section top and bottom chords, and equal angles for the web elements. The floor structure of the new plant deck was specified as lightweight steel C-Section members, supporting economy and constructability.

6. SUMMARY

BE Collective instigated an international project team which was successful in winning the stage 1 design for remediation and heritage preservation of the historic Africa Hall building in Ethiopia for the United Nations. Our company, supported by local sub-consultants provided detailed design reporting, in order to summarise condition assessment, structural analysis, and detailed design. It was identified that the building, now over 50-years old, has reached the end of its practical design life, requiring significant structural intervention.

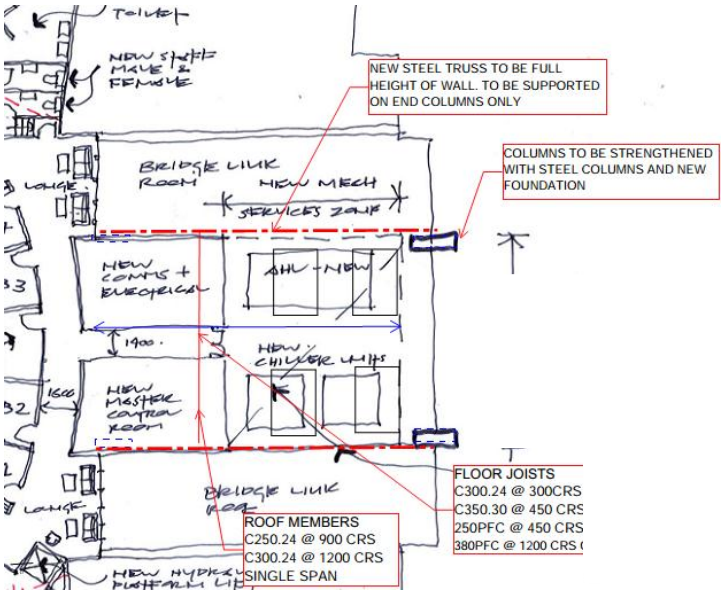


Figure 5 - Link Structure Sketch

The United Nations goal of updating the building to meet current international standards with respect to design and functionality was also supported via our nomination of:

1. Strengthening to reinforced concrete elements to accommodate imposed actions
2. Redmedial intervention in order to achieve compliance with respect to seismic performance
3. Retro-fitting in order to achieve compliance with international best practice for fire resistance
4. Practical incorporation of an additional floor above an existing link bridge structure.

Solutions were assessed and vetted against key performance criteria including cost, heritage preservation, spacial functionality, local contractor experience and materials availability. Feedback from the UNECA indicated the structural analysis and reporting provided by BE Collective was considered extremely comprehensive.