Structural Report

Memorial Hall - Waroona

Appraisal on Structural Suitability of Existing Structure – Main Hall

NRM Project Number 2017_1074

Shire of Waroona
Distribution Record

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For and on behalf of NRM Consultants

Signed: N R Mills  
Date: 6th Dec 2017

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NRM CONSULTANTS Project Name: Memorial Hall, Main Hall Roof Assessment – Shire of Waroona
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Structural Appraisal on Memorial Hall – Main Hall – Shire of Waroona

1.0 Introduction

NRM Consultants were requested to visit and provide recommendations for the continued use of the existing Memorial Hall – Main hall in Waroona by the Shire of Waroona. The investigation was undertaken on Friday 26th November 2017. Dr Nicholas Mills of NRM Consultants and Shire of Waroona Representative was on site at the time of inspection.

The existing Memorial Hall is a masonry construction building with full timber truss construction spanning across the full width of the building. The roof is metal sheeted, and the truss framing supports ceiling joists and roof purlins. The ceilings within the building span between the timber roof trusses picking up an old heavy ceiling construction and providing restraint to bottom chord. The timber trusses are engaged by full height masonry piers providing robust roof tie down provision.

Please note during our assessment, we did not inspect all elements of the construction, so the investigation does not transfer liability to the engineer. However, we provide these guidelines in this report to enable suitable and appropriate level of remediation to be undertaken on the building. It is our intention to provide an appropriate level of structural remediation recognising the cost constraints for a regional Shire. We believe the remediation specified are both appropriate and offer appropriate structural repair at a reasonable. We also believe that our discussions have opened potential new avenues for the internal appearance of the internal roof space. We expect due diligence always to ensure safety for all that enter and work around the building.

The main hall truss and roof support system was fully exposed for the structural assessment and inspection. The truss construction and the ceiling support joists were exposed to allow visual assessment of the structure. The report is limited to the visual inspection made and to the limits of a visual assessment. The report does not cover all members but provides a good overview on the structural integrity of the roof structure.

During our previous inspection on the memorial hall, it was noted that the existing truss construction to the main hall were split and perhaps under a degree of structural distress. It was requested in our previous report NRM Consultants 2017 – 1054 that an additional assessment on the main hall would be required. We noted at the time, that there was no immediate concern to this section of the building, whilst for the rear area, structural concern was noted.

The timber trusses were generally constructed from Oregon timber whilst the joist and ceiling hangers were generally constructed utilising Kari/Jarrah.

1.1 Technical Introduction

Splits and crack in wood are ruptures or separations in the grain of the wood which reduce the quality and performance of the timber. Not all splits and cracks in wood are caused by dry kiln or drying of timber. The splitting of timber can be separated into four categories, resource based, processing based, change moisture content and structural stress.

- **Resource based splits and cracks** – these are ruptures in the wood that occur in the tree or log. They are usually due to environmental conditions growth stress or activity of micro-organisms. Ring shake for example is the longitudinal separation of wood fibres in the tangential direction of the timber, and parallel to the growth rings. Ring shake can be caused by
tree age, wood structure and chemical composition. For some species, conditions such as large overmatured timber, excessive crook or sweep, poor site conditions are important factors regarding the formation of ring shake. In some species, it may be associated with timber wounds, injuries or disease. Ring shake is not a drying defect, originating in the standing tree. It only becomes apparent after drying;

- **Process splits and cracks.** Two major process based wood failures are in drying related and machine related damage. Much of major splitting in wood occurs during machining and is called loosened grain. Loosened grain is the actual separation of the wood along the growth ring on the surface of the wood. This failure is tangential direction i.e. parallel to the growth ring. Drying related damage occurs during the drying of the lumber, and categorised into three areas, surface check, end checks and internal checking or honeycombing. The cracking is usually in the radial direction, i.e. across the growth rings and not parallel to it. The rupture will generally extend across one or more growth rings.

- **Changing moisture** is dependent upon environment conditions and whether the environment is either wetter or drier than the moisture content of the lumber was dried at. The environment encompasses all environment during the processing, storage, shipment and final use of the product. Most drying will occur in the end grain of the timber, end dry quicker than sides and faces. If stress build up exceeds the strength of the timber then cracks develop. Some timbers are more forgiving than most. The greater the moisture content difference in the environment the higher the potential degree of cracking on the timber;

- **Structural splits and cracking** – usually result from mechanical damage during handling, transportation etc. or from improper or inaccurate design. Structural cracks will generally run at various angles to the main grain or growth rings. Some structural cracking can be introduced through the restraint introduced on the timber that prevents normal shrinkage and swelling that accompanies changes in humidity etc.

- Not all splits in timber are due to drying of the timber. However, generally, splits and cracks caused by drying extend across one or more growth ring in a radial direction. Mechanical damage or structural damage will run at various angles to the grain and growth rings.
2.0 General Observations

Many observations were made during the visit, NRM Consultants note the following:

- The main structure consists of timber fabricated roof trusses, with main timber members for compression and tie rods for tension members; these span between masonry piers. The pier centres are approximately 5m along the length of the building. The piers seemed robust during our inspection and offered no structural concern;

- A visual inspection of the external masonry did show some sign of historical settlement cracking, due to aged settlement and equilibrium. The cracking in the masonry observed was not structurally significant. However, one crack above an external door opening was noted, this will require monitoring and probably eventual repair, however, the saw immediate load transfer mechanism through the cast in lintel over the door opening. Please monitor, NRM Consultants can advise in the future if any remediation is required to this small element of masonry above the side door;

- The general condition of the existing trusses did vary, several observations were noted and widespread over the trusses observed;
  - Due to the age, a degree of shrinkage and drying cracks were apparent in the main timber members of the roof trusses. Some of the drying cracking could have been due to the adoption of unseasoned timber being utilised during the original build and the age of timber drying out over the years. Oregon timber has medium shrinkage potential. It is also possible some of the drying cracks are restrained shrinkage cracking;
  - Most of the cracking observed appeared to be down to non-structural issues or perhaps due to restraint on the timber during the timber swelling shrinkage during changes in moisture content in the environment;
  - The general connection to connection details appeared sufficiently robust during our observation, although one connection has displaced by about 10mm. In this location, a steel plate like the rear diner area would be required, once the connection had been fully adjusted and realigned;
  - The trusses were observed to have tie down provision for the wind loads on the roof. The tie downs extend into the external masonry piers and appears sufficient robust for a building of this age. As per previous reports on the Memorial Hall, we are unclear if they achieve current standards, and it is unexpected that they would achieve current regulatory status. If we repair the truss then current regulatory requirements do not have to be considered. We believe the tie down detail should be down to the external masonry pier foundation, as per standard structural requirements, however, observations could not confirm this full tie provision. Our perception is that this is not an immediate risk;

- The truss which carried the stage lighting has been put under considerable lighting from the lighting assembly. It has introduced additional vertical loading and torsional rotation on the main rafter chord, this has resulted in significant structural distress of the timber truss. It has also lead to additional deflection creep and joint creep opening on the truss. We don’t believe from our observations that the original truss was designed for this type of loading. The loading is to be removed completely;

- Some cracking was observed in the timber rafter chords of the truss. These were variable in length and width. It does suggest a degree of perhaps structural distress on the timber if they are angled from the main grain of the timber. However, if the principle stress in the timber is perpendicular to the main grain then tension cracks can occur along the main grain. The advantage for most timber trusses is that the forces are generally axial in nature with a small degree of bending moment. It is apparent that some additional torsion on re truss has opened up the truss rafter on one side of the rafter;

- In addition to this, a discussion is to be instigation on the provision of the ceiling joists off the bottom tie chord of the truss. We believe that this wasn’t the original intension of the truss design. Discussions indicate that the ceiling line as current adopted has been added later than the...
construction of the hall. The Shire of Waroona is to discuss the final ceiling layout in accordance with this report;

- We did note the splitting of many timber battens and compression flange restraints in the roof space. The integrity of ceiling joists, timber battens and compression restraints should be reviewed by a roof carpenter for integrity. We recommend then these are remediated to strengthen the joints to current requirements;
- We did note a portion of roof bracing on the front bay of the roof was missing. The bracing was pointed out to the Waroona representative on site at the time of the visit. The bracing to be introduced should mirror the stage end of the roof space using appropriately sized members;
- The ceiling joists appear to have rotated slightly. If the joists are to be reused, then it is prudent to introduce top flange restraint to all ceiling joists at mid-span, and at both ends;
3.0 Photographic Observations

Photographic observations are as followed:

- Figure 1a: Main Hall showing truss and exposed timber
  (The photos show the main trusses and ceiling hangers. Many of the existing truss frames were split to various degrees. Most joint connections on the truss were satisfactory, however, one joint had distorted significantly. The main ceiling joists were considered Jarrah / Kari. The general ceiling joist connections was ok but we would prefer an increased provision for top flange lateral restraint above what could be observed, if the ceiling is maintained.)
Figure 1b: Main Hall showing truss and exposed timber
(The photos show the general ceiling support and lighting bracket provision on the bottom chord of the truss. This bracket has introduced additional load on the timber that has not be allowed for in the original design. We recommend the removal of this load from the timber truss framing. The ceiling joists will require additional top flange restraint to prevent rotation on that compression fibre. Shire of Waroona to discussion option for ceiling location as the location observed, may not have been the original location.)
Figure 2a: - Truss 2 showing the dislodgement of main bottom chord from light frame loading (This frame has been loaded by a 200kg lighting frame. The frame is providing both a vertical load and an applied rotation to the bottom joint connection. We suggest this load is removed from the truss, as we believe the load has not been allowed for in the original design. The brackets have applied an eccentric load to rafter member, the existing plate has not been able to resist the rotation adequate hence the fibre of the timber has split. On the far side of the truss from this location, the timber rafter is split significantly.)
Figure 2b: - Truss 2 showing the dislodgement of main bottom chord from light frame loading
(This frame has been loaded by a 200kg lighting frame. The frame is providing both a vertical load and an applied rotation to the bottom joint connection. We suggest this load is removed from the truss, as we believe the load has not been allowed for in the original design. The brackets have applied an eccentric load to rafter member, the existing plate has not been able to resist the rotation adequate hence the fibre of the timber has split. The fracture on the main rafter timber is significant and will probably require a degree of reinforcement introduced in to the timber, utilising a technique called Wood Epoxy reinforcement. The rebars are grouted at an angle to the shear fracture, this is a potential specialised remediation. This current stress fracture is along the existing bolt line, we would suggest from our observations that the joint will continue to open and will need significant remediation. The crack on this side is approximately 5 – 6mm thick and may have been infilled previous remediation.)

Joint opening very apparent on the bottom chord due to lighting brackets.

Significant stress fracture during rotation on main rafter member. Fracture is parallel to the grain.
Figure 2c: - Truss 2 showing the dislodgement of main bottom chord from light frame loading
(This frame has been loaded by a 200kg lighting frame. The frame is providing both a vertical load and an applied rotation to the bottom joint connection. We suggest this load is removed from the truss, as we believe the load has not been allowed for in the original design. The brackets have applied an eccentric load to rafter member, the existing plate has not been able to resist the rotation adequate hence the fibre of the timber has split.)

Splintered timber to be remediated with Wood epoxy and reinforcement, or if absolutely required a proprietary plate system, to be confirmed.
Figure 3a: - Ceiling joists should have top fibre restraint

(We recommend that the existing timber joists are strengthened on the top fibre at mid-span and end support location to provide restraint from compression loading. The Shire of Waroona is to have a discussion on the ceiling covering and the location of the ceiling interface.)
Figure 4a: - Tie down provision to truss structure

(A vertical tie down provision was provided to all trusses. Expected that the vertical tie is vertically cast into the existing pier. Observation could not confirm this; however, we believe that the tie down provision is sufficient although, it may not achieve current code requirements. Typically, the roof tie-down would be resisted by the big masonry piers to the external face of the masonry on the hall. We expect this provision is suitability robust at this time.)
Figure 5a: - Timber roof battens

(It is observed that many timber battens/restraints were split or cracked as shown. These details are to be remediated as necessary by a roof carpenter. The roof requires a general overview by a roof carpenter, with roof joints upgraded as necessary to achieve strength provision requirements.)
Figure 5b: - Timber roof battens

(It is observed that many timber battens were split or cracked as shown, a consequence generally of age. These details are to be remediated as necessary by a competent roof carpenter. The roof requires a general overview by a roof carpenter, with roof joints upgraded as necessary to achieve current strength provision requirements.)
Splitting of timber battens / restraint. To be remediated. The use of wood filler epoxy can be recommended in certain situations.

Figure 5c: - Timber roof battens
(It is observed that many timber battens were split or cracked as shown. These details are to be remediated as necessary by a roof carpenter. The roof requires a general overview by a roof carpenter, with roof joints upgraded as necessary to achieve strength provision requirements.)
Figure 5d: - Timber roof support

(It is observed that many timber battens were split or cracked as shown. These details are to be remediated as necessary by a roof carpenter. The roof requires a general overview by a roof carpenter, with roof joints upgraded as necessary to achieve strength provision requirements. It is possible to add sarking and insulation battens to the roof sheeting in this location, at the discretion of the Shire of Waroona)
Figure 6a: Examples of the existing timber member splitting due to drying and load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. The splits in the timber shown is most probably due to shrinkage and restraint, and resin epoxy is the most appropriate course of remediation down to a certain crack with. For narrow cracks the resin may have to be gravity injected from above to the cracked plane.)
Figure 6b: - Examples of the existing timber member splitting due to drying and load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. The splits in the timber shown is most probably due to shrinkage and restraint, and resin epoxy is the most appropriate course of remediation down to a certain crack with. For narrow cracks the resin may have to be gravity injected from above to the cracked plane.)
Figure 6c: - Examples of the existing timber member splitting due to drying and load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. The splits in the timber shown is most probably due to shrinkage and restraint, and...
resin epoxy is the most appropriate course of remediation down to a certain crack with. For narrow cracks the resin may have to be gravity injected from above to the cracked plane.)

**Figure 7a:** - Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 7b: - Examples of the existing timber member splitting due to drying & load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 8a: - Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Hairline split on timber member. These are stress due to structural actions rather than drying. It is recommended that wood epoxy and reinforcement may be required in this location, however, proprietary plates could be utilised if deemed appropriate.

Figure 8b: - Examples of the existing timber member splitting due to drying & load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 8c: - Examples of the existing timber member splitting due to drying & load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. Epoxy resin in this location should be deemed sufficient.)
Figure 9a: Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 9b: - Examples of the existing timber member splitting due to drying & load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 9c: Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)

Hairline split on timber member. These are stress due to moisture movement on the ends of the truss rafter. Resin remediation.
Figure 10a: - Examples of the existing timber member splitting due to drying & load stress
(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance.)
Figure 11a: Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber that is old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. We expect wood epoxy resin and reinforcement in this location, however, proprietary plate fixing may be required, subject to final discussions with specialist contractor.)
Figure 11b: - Examples of the existing timber member splitting due to drying & load stress

(Many observations were made on the timber trusses where physical splitting of the timber could be observed. Some of the timber splitting was a consequence of potential age drying and shrinkage, although some cracking was potentially due to stress from loading. It is suggested that the timbers installed may not have been fully seasoned prior to installation. Timber this old is expected to have split due to shrinkage and drying, as observed. The splits are to be remediated with monitoring on the building to ensure continued structural performance. We expect wood epoxy resin and reinforcement in this location, however, proprietary plate fixing may be required, subject to final discussions with specialist contractor.)
Figure 12a: - Member connection – loss of connectivity
(At this location the connection of a compression strut has slipped out of location. The truss is to be remediated to ensure that the connection is realigned. The tension rods present on the truss structure may require realignment and tensioning)

Member connection to be realigned on site and the truss frame tightened to prevent deformation. A metal plate strengthening plate may be required at this location.
Figure 12b: - Truss Typical connections are satisfactory in the main
(Observations do indicate that the truss joints are satisfactory. The failure of the truss appears in the timber fabric rather than at joint interface, similar to those we saw in the Supper / Kitchen area of this building.)

Figure 13a: - Truss 2 – Slip on bottom chord
(Some potential slip on bottom chord member due to the additional ceiling roof loadings.)
Figure 13b: - Eaves Beam Splitting
(Observations indicate a significant split on this eaves beam, we suggest epoxy remediation and additional support to the masonry below. The contractor can replace or strengthen the timber with plates if they deem additional work is required.)
4.0 Recommendations

Based upon our assessment, a degree of remediation is required. Some of the remediation’s are required as a matter of urgency. Please consult with the contractor on the appropriateness of all remediation’s. We are happy to be engaged further to provide additional advise as necessary.

4.1 Recommendations and Conclusions

- The structure is showing age deterioration. Although the trusses may have sufficient structural integrity for the lighter roof with the ceiling removed, we recommend that all remediation is undertaken promptly. We believe that an exclusion zone should be maintained in this hall, not because of the large danger of a failing structure but to mitigate any risk to the public and stakeholder. If propping is required to any truss frame it is the truss frame that carried the lighting frame;
- We recommend that the remediation works is undertaken promptly with structural engineering oversight as per previous works on the building. We also recommend that the Shire review the acoustic roof system to work with a potential new aesthetics on the building;
- We have discussed the works with a specialist heritage remediation contractor. Due to the specialist nature of the works, we recommend that a specialist Contractors are engaged. A specialist in old building remediation can offer advice about constructability and practicability with respect to heritage remediation;
  - Remediation specialised contractor, we recommend that such services are engaged to undertake the remediation repairs in the building;
  - The contractor is to have significant experience on the remediation of similar heritage buildings and / or the use of structural remediation systems such as wood epoxy and reinforcement. We believe the current memorial Hall building is a regional heritage building and consequently is not a fully listed building. The Shire of Waroona should assess the experience of any contractor with consideration to the remediation of similar building utilising similar remediation and specialist methods;
- During our investigation, we assumed that the ceiling finishes to the truss and the original plaster finish to the ceiling were part of the original construction. It appears that there is a possibility that the original roof construction was fully open and exposed. The Shire may have a desire to remediate the existing ceiling to open up the roof space. This consequently entails the following: -
  - It appears that it is advantageous to incorporate an acoustic ceiling that is lightweight, rather than maintain an acoustic panel that is heavy;
  - It appears it may be possible to remove the existing ceiling joists and systems, and move the new acoustic ceiling up towards the existing roof line;
  - We recommend that sarking is added to the underside of the existing roof finish, along with insulation battens and acoustic panelling;
  - It has been suggested in discussions that the imposition of the joists and ceiling has introduced additional loading to the truss member that was not originally design for. I.e. the ceiling loads are bearing off the bottom truss element of the tie chord. It is currently assumed that the original design did not allow for this ceiling loading as a design intent. Due consideration should be made to potential removing the load from the tension chord to the main rafter or purlin locations. A structural engineer would require engagement to ensure that the existing joists are sufficient to accommodate the new roof applied loadings;
    ▪ We believe the truss would perform better if the ceiling load position as adjusted back to perhaps the original load location;
  - We recommend a new floating acoustic and lightweight ceiling if possible, with the option, at the Shire of Waroona’s discretion to move the new ceiling line up to the
existing rafter line. It is possible to hang the roof ceiling off the existing purlin and rafter lines;
  o The removal of the existing timber joists and ceiling may probably improve the structural performance of the truss structure;
  o NRM Consultants are happy to provide additional engineering support in delivering this requirement, at the discretion of the Shire of Waroona;
  o Lighting support provision can be accomplished with the introduction of new LVL spanning between trusses to pick up the existing lighting rigs;

- The roof space and the existing truss structures are aged, and do show a degree of aged cracking and some shrinkage. Whilst many of the cracks and splits are aged and perhaps due to drying shrinkage, several cracks are structural in nature due to the change in original load intent on the structure. It is prudent to readdress the loading provision in the existing trusses; we make the following recommendations with respect to the loading arrangement:
  o The lighting truss frame support is to be removed off the existing truss and relocated to engineering requirements, specified by the appointed engineer. We believe that the truss lighting support can be relocated to the roof purlin or to the truss top chord, subject to engineering confirmation;
  o The new ceiling is recommended to be lightweight if possible, as the existing gypsum provision and joists ay have added additional load support to the wrong element of the truss. It is possible to install a floating ceiling hanging from the purlins. We suggest further discussion with the Shire of Waroona to determine the best position of the ceiling and acoustic panels to suit their needs. The engagement of an acoustic expert may be prudent to assess the location of the panels, if the Shire of Waroona deem this is an important criterion;

- We believe that the cracks in the timber trusses can be remediated utilising a process of wood epoxy resin or Wood epoxy and reinforcement remediation (WER). In the worst locations, a plate strengthening exercise may be required as per the supper and kitchen truss area. However, we believe that the resin will repair 90% of the timber cracks observed without significant interruption to the roof space;
  o One truss is significantly damaged, that is the truss carrying the existing lighting truss. This truss requires the highest degree of remediation and potential strengthening. We expect this truss to be remediated utilising the wood epoxy resin and reinforcement technique with perhaps a strength gang plate or hoop plate to the timber or even timber ply strengthening. Tek screwed both sides of the main rafter member. It is our aim, that if the roof space is to be opened then we would prefer a none intrusive remediation and that is why the resin and reinforcement remediation would be ideal;
  o Discussions with our specialist indicate that the philosophy of resin remediation with some reinforcement strength is a practical solution;
  o We recommend that a heritage specialist is engaged, with oversight on all remediation and repairs in accordance with a competent engineering supervision;
  o We have been advised that the resin approach is a practical approach and it offers advantages over significant structural repair or timber truss replacement. We don't believe that the trusses require immediate replacement, however the remediation to that one truss is recommended quite promptly. We recommend that the building remains closed until these remediation's have been undertaken. We apology for any inconvenience this may cause, however, we do have to consider the inherent risk to those that utilise the main hall building. We are not saying there is an immediate risk, because we don’t believe there is, but the risk must be managed with respect to stakeholder and user safety;

- One truss identified during our observations has a timber to timber connection that requires remediation. The remediation should be relatively straight forward. The existing truss
should be jacked under the centre of the truss to relieve the stress on the compression strut so that it can be realigned with the existing timber notch in the rafter. A degree of tension chord tightening may be required to maintain the integrity of the truss. If this is deemed insufficient that a remediation plate as per the supper extension works can be adopted. We don’t believe this is necessary now;

- We recommend that an appropriate specialist is engaged to undertake the remediation of the timber truss works, as this is specialist construction. We believe it is prudent for any specialist remediation contractor to attend a site visit to underside the degree of remediation required on the site. As part of the tendering process, we recommend that the Shire of Waroona should organise a mandatory site visit;
  - We are happy that a non-specialised contractor can continue with the installation of the roof and undertake general remediation repair to the roof space and installation of the new ceiling;
- We recommend that general remediation is undertaken on the existing roof purlins and battens. We suggest that discussions are held with the appointed specialist contractor to align the final remediation in accordance with the desire aesthetic to the new opened roof space;
  - This would include replacing appropriately structurally reduced timber sections such as cracked battens, batten to timber connections, deteriorated joists or damaged joists;
  - We suggest that a bracing timber is added to the front bay of the building to mirror the existing bracing provision in the structure. The bracing is to match the existing provision in sizing and member fixity;
  - We suggest that the existing ceiling timbers are given adequate compression flange restraint provision. We suggest that the ceiling joists are restrained on the top flange at mid-span and at each bearing end.
  - Due consideration should be given to the Local Heritage status of the structure.

- Our specialist makes the following comments on our discussions:
  - They consider the conservation approach by NRM Consultants to be practicable, given the age and state of the building. The methodology able to deliver the desired outcome whilst providing sufficient opportunity for ongoing review and analysis to determine the most effect remediation works;
  - The remediation approach recommended for the epoxy resin repair will have less impact on the structure, alternative remedial connections may be required in some situations, as discussed in our report;
  - Additional timber sources should be sourced from salvage yards, as these timbers will be dry and of appropriate age, limiting the risk of ongoing cracking or movement. This is subject to engineering verification by NRM Consultants or appointed Structural Engineer;
  - They also consider the ceiling is be an addition to the structure. Consideration should be made to opening the roof space as per the original configuration;
  - They too recommend that the remediation is undertaken by a specialist in heritage building works. NRM Consultants appreciate that the building is not full state heritage but is local heritage. The Shire of Waroona are to provide advice on the heritage content of any remediation package required with the contractor;
  - All addition, NRM Consultants recommend that the Shire of Waroona explore the opportunity to meet any specialised contractor on site for a more detailed assessment of the building. NRM Consultants would like to attend this meeting, to aid in the discussion with the recommended sub-contractor. As discussed earlier, a mandatory site visit for tender would be recommended.
5.0 General Notes

STRUCTURAL NOTES  (General Generic Guidelines)

GENERAL

1. MAINTAIN THE STRUCTURE IN STABLE CONDITION DURING REMEDIATION. NO PART SHALL BE OVERSTRESSED. PROVIDE TEMPORARY BRACING AS REQUIRED.

2. ALL WORKMANSHIP AND MATERIALS SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE SAA CODES AND THE BY-LAWS AND ORDINANCES OF THE RELEVANT BUILDING AUTHORITY.

3. DATUM FOR LEVEL IS LOCAL.

4. NOMINATION OF PROPRIETARY ITEMS DOES NOT INDICATE EXCLUSIVE PREFERENCE BUT INDICATES THE REQUIRED PROPERTIES OF THE ITEM. SIMILAR ALTERNATIVES HAVING THE REQUIRED PROPERTIES MAY BE OFFERED FOR APPROVAL.

5. THE STRUCTURAL WORK SHOWN ON THE DRAWINGS HAS BEEN DESIGNED FOR THE FOLLOWING LOADS:
   a. WIND LOADS: 45M/S
   b. LIVE LOADS: Roof 0.25KPa

TIMBER

1. ALL WORKMANSHIP AND MATERIALS SHALL BE IN ACCORDANCE WITH AS 1720.

2. ALL TIMBER FRAMING SHALL BE IN ACCORDANCE WITH AS 1684 INCLUSIVE OF SUPPLEMENTS.

3. U.O.N. ALL TIMBER SHALL HAVE A MINIMUM STRESS GRADE OF F11 OR MGP10, OR IN ACCORDANCE WITH ORIGINAL DESIGN DOCUMENTATION;

4. ALL CLEATS AND BUILT IN STEEL WORK SHALL BE HOT DIPPED GALVANISED.

5. MINIMUM CLEAT SIZE SHALL BE 6mm PLATE WITH 2/M12 GRADE 4.6 BOLTS. WASHERS SHALL BE USED AT HEAD AND NUT IN ACCORDANCE WITH AS 1720.

6. FOR BOLTED CONNECTIONS GENERALLY THE FOLLOWING DIMENSIONS SHALL APPLY U.O.N.

   END DISTANCE = 5 x D

   SPACING PARALLEL WITH GRAIN = 4 x D

   EDGE DISTANCE = 4 x D

   SPACING PERPENDICULAR TO GRAIN = 5 x D

   WHERE 'D' IS DIAMETER OF THE BOLT USED.

7. PROVIDE SOLID TIMBER NOGGINS AT TIMBER PLATE SUPPORT LOCATIONS AND MIDSPANS FOR SPANS SPECIFIED IN AS 1684.

8. TIMBER TREATMENT: ALL TIMBER IS TO BE TREATED. * ABOVE GROUND TIMBER SHALL BE TREATED TO H3 LEVEL MIN.

TRUSS MANUFACTURE AND ERECTION

1. TRUSSES SHALL BE DESIGNED AND FABRICATED BY AN APPROVED TRUSS MANUFACTURER.

2. BASIS OF THE DESIGN SHALL BE IN ACCORDANCE WITH FOLLOWING AS APPLICABLE –
   a. AS 1170, PARTS 1 TO 4
   b. AS 1720 TIMBER ENGINEERING CODE
   c. AS 4600 COLD FORMED SECTIONS
   d. AS 4100 STEEL STRUCTURES CODE.
e. CONTRACT DRAWINGS

f. ALLOW FOR SERVICE LOADS AS REQUIRED BY MECHANICAL
SUBCONTRACTORS, HOT WATER SYSTEMS ETC.

3. THE DESIGN SHALL COMPRIZE TRUSSES, CONNECTIONS, TIE-DOWNS BRACING, WIND TRUSS CAMBER AND INTEGRATION WITH THE REST OF THE STRUCTURE UNLESS SHOWN OTHERWISE. DRAWINGS AND CALCULATIONS SHALL BE SUBMITTED TO THE SUPERINTENDENT FOR APPROVAL PRIOR TO FABRICATION.

4. ROOF BRACING SHOWN ON DRAWINGS IS FOR OVERALL STABILITY TO THE STRUCTURE. TRUSS MANUFACTURERS SHALL DESIGN ADDITIONAL BRACING AS NECESSARY FOR STABILITY OF THE ROOF TRUSS SYSTEM BUT MAY USE BRACING SHOWN TO ASSIST WHERE REQUIRED.

5. WEB MEMBERS WHERE SHOWN ARE DIAGRAMMATIC ONLY. FINAL DESIGNATION OF MEMBERS SHALL BE TO MANUFACTURERS REQUIREMENTS.

6. INSTALLATION OF TRUSSES SHALL BE IN ACCORDANCE WITH THE MANUFACTURERS RECOMMENDATIONS.

7. THE TRUSS MANUFACTURER SHALL INSPECT THE ROOF STRUCTURE ON COMPLETION OF TRUSS ERECTION AND SHALL PROVIDE THE SUPERINTENDENT WITH WRITTEN CERTIFICATION THAT THE TRUSSED ROOF CONSTRUCTION IS IN ACCORDANCE WITH THE DESIGN AND CONTRACT DOCUMENTS.

8. NOT MORE THAN 1 IN 3 BATTENS TO BE SPLICED ON ONE TRUSS.

9. THE TRUSS DESIGNER SHALL PROVIDE DETAILS OF ALL PLATES AND CLEATS TO BE ATTACHED TO STEELWORK TO SUPPORT ROOF TRUSSES.

10. DEFLECTION OF TRUSSES TO BE LIMITED TO SPAN/600 UNDER LONG TERM DEAD LOAD. MINIMUM CAMBER 5mm.

11. MAXIMUM TRUSS SPACING 900mm.

12. ALL SCREWS AND BOLTS TO BE GALVANISED.

13. MINIMUM TIE-DOWN OF EXTERNAL WALL PLATE TO BE 30x0.8mm GI STRAPS AT EACH SIDE OF CORNERS AND OPENINGS AND MAX. 900 CENTRES ELSEWHERE. BUILD IN STRAPS MIN. 150 INTO BED JOINT 18C DOWN AND FIX TO RAFTER WITH 4/2.8mm DIA. NAILS AT EACH SIDE OF OPENINGS OVER 1.5m WIDE PROVIDE A FULL HEIGHT STRAP. TENSION STRAPS TO REMOVE SLACK PRIOR TO FIXING TO TOP PLATE OR RAFTER.

TIE-DOWN

1. PROVIDE ROOF TIE DOWN IN ACCORDANCE WITH AS 1684 FOR THE APPROPRIATE WIND CLASSIFICATION OF N1;

2. TIE DOWN EXTERNAL WALL PLATE WITH 30x0.8mm PGI STRAPS AT EACH SIDE OF OPENINGS AND AT 900 CTS ELSEWHERE. STRAPS TO BE BUILT-IN TO BED JOINTS MIN. 18C DOWN. TENSION STRAPS AND FIX STRAPS TO WALL PLATE OR TO RAFTERS WITH 4/3.15 DIA. GALVANISED CLOUTS.

3. TIE DOWN ROOF BEAMS WITH 10mm DIA. GALV RODS TO FLOOR LEVEL. BUILD LOWER END INTO FLOOR SLAB OR COG MIN. 150mm INTO WALL. TIE DOWN ROD MAY BE LOCATED IN CAVITY OR CHASED MAX. 10mm INTO WALL.

4. BOLT VERANDAH BEAMS/LINTELS TO POSTS WITH 2/M12 BOLTS. PROVIDE FULL HEIGHT 10mm DIA. ROD IN BRICK PIERS.

5. PROVIDE ADEQUATE HOLD DOWN FIXING TO BATTENS, RAFTERS, UNDERPURLINS AND THE LIKE TO TRANSFER ALL UPLIFT FORCES TO THE RESISTING ELEMENTS.
Appendix

Dr. Nicholas Mills
NRM Consultants
Unit 1/9 Breakwater Parade
MANDURAH WA 6210

30 November 2017

Dear Nicholas,

WAROONA MEMORIAL HALL STRUCTURAL REMEDIATION WORKS

Further to your request, AE Hoskins & Sons has undertaken a preliminary assessment of the Structural Report dated 29 November 2017, prepared for Shire of Waroona, to assess the viability and practicality of the proposed remedial works to the Memorial Hall.

Based on our telephone discussion and review of the Structural Report, AE Hoskins & Sons considers the proposed conservation approach to be the most practical option available, given the age and current state of the building.

The proposed approach is quite conservative and we are confident it will be able to deliver the desired outcomes, whilst also providing sufficient opportunity for ongoing review and analysis of the effectiveness of the works.

In relation to the specific scope of works recommended, we would advise that the awarded Contractor would need to consider the following:

1. Whilst the remedial approach recommended for the epoxy resin repair technique will have less impact on the structure and limit the loading, alternative remedial connections may be required in some situations. We would recommend any such works are reviewed to ensure a suitable outcome, which meets typical heritage standards, prior to works continuing.
2. Any additional timber members should be sourced from a salvage yard; as these timbers will be dry and of an appropriate age, limiting the risk of ongoing cracking or movement. This will result in a higher structural grade, as well as retaining the heritage fabric of the building.
3. We consider it likely that the existing plaster acoustic ceiling is a later addition and not the original ceiling. We believe the ceiling space would have been open, with the exposed truss configuration in its natural framework.
More broadly, we would recommend these works be completed by a specialist in heritage building works, with demonstrated experience in structural remediation. As noted in the designs, many of these works will be bespoke, requiring a Contractor with a thorough knowledge of heritage requirements, to ensure the structural integrity of the final solution.

We would welcome an opportunity to meet on site and provide a more detailed assessment of the building, based on an inspection of the exposed roofing structure, along with yourself.

Should you require any further information, please feel free to contact our offices on the details provided.

Yours sincerely,

[Signature]

Michael Hoskins
Registered Builder