UNITY AND FREEDOM

MALAWI GOVERNMENT

SAFER SCHOOL CONSTRUCTION GUIDELINES

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MINISTRY OF EDUCATION

MALAWI DEPARTMENT OF DISASTER MANAGEMENT AFFAIRS

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Glossary

It is widely acknowledged within the disaster community that hazard and disaster terminology are used inconsistently across the sector, reflecting the involvement of practitioners and researchers from a wide range of disciplines. Key terms are used as follows for the purpose of this guidance note series.

Climate change

Climate change is a statistically significant change in measurements of either the mean state or variability of the climate for a place or region over an extended period of time, either directly or indirectly due to the impact of human activity on the composition of the global atmosphere or due to natural variability.

Disaster

A disaster is the occurrence of an extreme hazard event that impacts vulnerable communities causing substantial damage, disruption and possible casualties, leaving the affected communities unable to function normally without outside assistance.

Disaster risk

Disaster risk is a function of the characteristics and frequency of hazards experienced in a specified location, the nature of the elements at risk, and their inherent degree of vulnerability or resilience.

Mitigation

Mitigation is any structural (physical) or non-structural (e.g. land use planning, public education) measure undertaken to minimise the adverse impact of potential natural hazard events.

Natural hazard

A natural hazard is a geophysical, atmospheric or hydrological event (e.g. earthquake, landslide, tsunami, windstorm, wave or surge, food or drought) that has the potential to cause harm or loss.

Preparedness

Preparedness refers to the activities and measures taken before hazard events occur to forecast and warn against them, evacuating people and properties when they threatened and ensuring effective responses (e.g. stockpiling food supplies).

Relief, rehabilitation and reconstruction

Relief, rehabilitation and reconstruction are any measures undertaken in the aftermath of a disaster to, respectively, save lives and address immediate humanitarian needs, restore normal activities and restore physical infrastructure and services.

Vulnerability

Vulnerability is the potential to suffer harm or loss, related to the capacity to anticipate a hazard, cope with it, resist it and recover from its impact. Both vulnerability and its antithesis, resilience, are determined by physical, environmental, social, economic, political, cultural and institutional factors.

Foreword

Malawi has been traditionally vulnerable to disasters because of its unique geo-climatic conditions. Thus Malawi's vulnerability is primarily linked to specific geo-climatic factors that include: (i) the influence of the El Nino and la Nina phenomena on the country's climate, and the tropical cyclones developing in the Mozambique Channel, resulting in erratic rainfall patterns; and (ii) the location of the country along tectonically active boundary between two major African plates within the great East African Rift Valley System, causing earthquakes and landslides. From 1979 to 2008, natural disasters affected nearly 21.7 million people and killed about 2.596 people. The main types of natural hazards include floods, droughts, earthquakes, windstorms and landslides.

The country also faces human- induced and biological disasters, such as environmental degradation and epidemics respectively. Their intensity and frequency are likely to increase in the light of climate change, population growth and continued environmental degradation as evident in the earthquake disaster that hit Karonga and Chitipa in 2009/2010 as well as the floods of 2014/2015 that caused severe damage to Schools, houses, property and loss of lives. The trend continues every year making learners disadvantaged with regards to right to education. The most effective measure to protect the lives of learners and teachers, and property is by building better and safer schools and houses, particularly in rural areas, to minimize damage.

In rural areas, construction of schools is mainly done by local artisans with limited knowledge and technical skills. They construct school structures and houses without guiding manuals, regulation and standards. Consequently, initial construction guidelines were developed in 2010 by the Government of Malawi, through the Ministry of Lands, Housing and Urban Development, following a series of earthquakes that occurred in Karonga and parts of Chitipa Districts to provide the needed guidance.

However, several gaps in the guidelines were identified (World Bank Mission, 2012), several lessons were gathered by stakeholders, and the limited stakeholder awareness of the first guidelines necessitated the revision.

The need for guidelines that would also ensure safety of learners during recurrent disasters cannot be overemphasized evidenced by the unprecedented increase of losses and damages incurred in the education sector. In responding to the devastation in the education sector, Government through the Malawi Floods Emergency recovery Project (MFERP) with support from the World Bank facilitated the development of Safer Schools Construction Guidelines (SSCGs) to fulfill the requirements for Building Back Better and Smarter in the in reconstruction and rehabilitation of disasters' damaged school infrastructures.

These Safer Schools Construction Guidelines promote local practices, low-cost technologies and identify strategies for multi-hazard risk reduction by proposing both affordable and appropriate solutions through a user-friendly manual. Nevertheless, the manual remains a living document and should form the basis for mainstreaming disaster risk reduction in both education sector and construction of schools in Malawi. All stakeholders are called upon to utilize the guidelines in ensuring quality and safety of school's infrastructures for quality education in Malawi. The Malawi Government recognizes with gratitude the technical and financial support of the World Bank, with funding through MFERP, the Global Facility for Disaster Reduction and recovery. Government further acknowledges the contribution from Bureau TNM consulting firm and the Arup International Development for facilitating the development process and all stakeholders who immensely contributed in the development of the guidelines.

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MINISTER OF EDUCATION SCIENCE & TECHNOLOGY

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The Need for Safer Schools

In 2015 Malawi was severely affected by floods and droughts. Assessments indicate that the floods displaced more than 250,000 people, killing more than 270, with 15 districts and 638,645 people affected. Such natural disasters often damage or destroy education infrastructure, threatening educational opportunities and risking the lives of school children. Recent efforts to improve education have focused on school disaster management and risk reduction education. This is now being complemented with a focus on the physical safety of safer learning facilities, in line with Goal 4 of the Sustainable Development Goals (SDGs).

The Global Program for Safer Schools (GPSS) was launched by the Global Facility for Disaster Reduction and Recovery(GFDRR) as a technical assistance program that targets countries where there is an ongoing or proposed investment in education infrastructure. It aims make school facilities and the communities they serve more resilient to natural hazards. The program works to reduce the physical impact of disasters on education infrastructure and minimize the negative educational outcomes that result from disasters.

As a pragmatic and proactive measure to address some of the key challenges faced by the Education Sector, in 2017, the Government of Malawi, through the Ministry of Education initiated a project to support the Safer Schools agenda, leading to the publication of this Safer Schools Construction Guidelines.

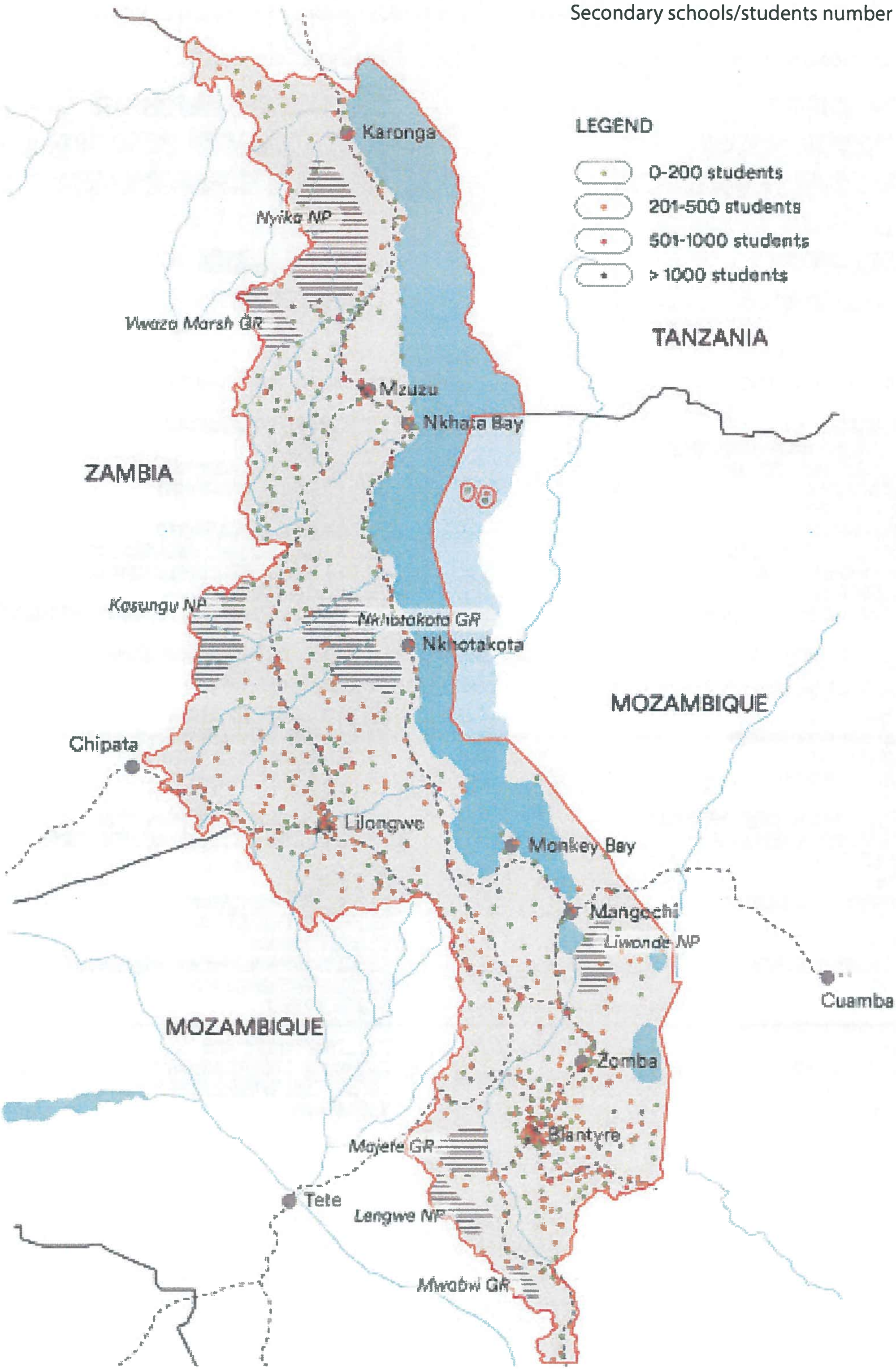
Building safer and resilient schools is an opportunity for the country of Malawi to provide a safe environment to the learners, to upgrade the building stock, to enhance and improve construction practices throughout the country, and to provide, in case of disaster, safe havens to the local communities.

Context

The school infrastructure baseline and construction environment in Malawi exhibits the following characteristics:

- Malawi is affected by a number of natural hazards, which causes significant impact to the built environment generally and to schools in particular
- A high demand exists for school infrastructure nationally and is predicted to continue. Supply is increasing nationally but there is limited capacity in the planning of the delivery of this infrastructure.
- There is little evidence that site selection and physical planning of the school sites is undertaken or is hazard-responsive, with many schools across the country located on exposed sites. Sites for schools are frequently selected by local communities, without any understanding of the prevalent hazards.
- Many schools display structural vulnerabilities which increase their susceptibility to damage from natural hazards, arising from a lack of engineered school designs appropriate to the site, poor quality materials, poor quality control and supervision during construction and a lack of maintenance of school infrastructure
- From a regulatory perspective, planning regulations are not uniform or consistently present throughout Malawi. Land-use plans that incorporate hazard data do not exist. In city and municipal areas, the Town and Country Planning Regulations (1986) are noted to apply, which require proposed developments to be approved in the context of area development plans. However, outside of major urban areas, it appears that limited if any planning considerations or site appraisals are carried out in advance of construction of new developments.
- In terms of Building Regulations, the Malawi Building Code is in process of being established. This will provide the opportunity to review regulatory documentation and establish a hierarchy for compliance and enforcement mechanisms.

Secondary schools/students number



Purpose of Safer Schools Construction Guidelines

The Safer School Construction Guidelines contain a framework of principles to guide the construction of resilient and safer school environments, tailored to Malawi. It is intended to be used for the construction of new school buildings and is tailored for construction in rural areas, where most of the school construction is taking place. However, the guidance provided is also generally relevant in an urban context, even if some urban-specific issues are not addressed. Furthermore, much of the guidance in this document relates to good practice in planning, design and construction in the built environment in Malawi and can be used widely.

In this V1 of the SSCG, it is assumed that the guidelines will be used by suitably qualified technical personnel, who will adapt the guidelines to the specifics of a particular site and that the construction works will be carried out by a competent contractor.

It is important to note that some of the details included in the SSCG will need to be adapted to the specifics of a particular location/site school design by appropriately qualified technical personnel, as it is not possible to address every design situation within a document such as this. However, this document sets out to illustrate the key design principles to be considered in such an adaptation, in addition to robust, best practice construction detailing.

The guidelines are designed to meet the following main objectives:

- Save lives, through addressing multiple hazards in the planning, design and construction of new school buildings
- Reduce the physical impact of natural disaster on school infrastructure
- Increase quality throughout the entire planning, design and construction of school buildings
- Bring innovation and be transformative in planning, design and construction processes and techniques
- Address different cost-effective solutions (future revisions) of the SSCG
- Provide sustainable and adaptive solutions addressing current challenges.

The Safer School Construction Guidelines considers the different hazards in the country and how the site selection and site planning processes to place the school buildings respond to these hazards. The document builds upon the existing knowledge and output already approved by the Ministry of Education in relation to model school layouts and specification. It considers the materials and construction techniques in use in Malawi.

The SSCG seeks to provide feasible solutions to enhance the construction of school buildings, by targeting the selection of proper sites, by improving the site planning process, by improving the layout of the buildings, by considering the quality of the materials, by improving the construction techniques and by suggesting maintenance activities.

Intended Readership

This document has been written for a broad readership, with a particular emphasis on the technical stakeholders who directly impact on the construction of school infrastructure. These technical stakeholders include the EIMU, school designers and contractors, INGOs and NGOs. The technical staff in those bodies will be competent at reading technical drawings, but other readers may not. The technical staff in the contractor firms can use the SSCG to provide non-technical staff with a good level of understanding to check and monitor construction, providing another level of quality assurance (QA).

The SSCG will also be useful in fostering cross department collaboration in national and local government, by providing a common standard which will underpin school planning design and construction, irrespective of the funding mechanism.

It is anticipated that different chapters of the guidance will be used by different stakeholders. The table on the next page identifies primary and secondary audiences for each chapter and how they will use the document.

The primary readership includes those who are key decision makers at a particular point in the process or those who are expected to implement an activity (e.g. build the school building). The secondary readership includes those who would gain useful information and increase their awareness of an issue by reading a particular section.

It may be the case that in some instances, responsibility for certain decision making activities are idealised only and do not reflect current practice. However, one of the purposes of this document is to effect change in the process and as such, it is important to identify appropriate stakeholders for the key activities in the school infrastructure implementation process.

How To Use This Document

In Appendix A, an overall project implementation workflow for national level school infrastructure projects is included. Along with this, a responsibility matrix is also included, which defines those who should lead and support key activities at each stage of the implementation of a project. These documents indicate which Chapter of the SSCG should be used at each stage. Each chapter provides guidance as noted in the Overview of Contents above.

Design of the site and of the school buildings may need to be adapted to suit:

1. Hazards
2. Soil/ ground conditions
3. Materials (availability, cost, local skills and preference)

In terms of hazards, the design should respond to the relevant hazard using the following principles:

Avoid

In the first instance and wherever possible, hazards should be avoided through Site Selection (Chapter 3: Site Selection)

Mitigate

In some cases, it may not be possible to completely avoid a hazard, for example where an entire community is living on a floodplain. In these instances, the hazard should be mitigated as far as possible through design adaption of the site (Chapter 4: Site Planning) and/or of the school buildings (Chapter 5: Design) themselves.

Disasters are an increasing threat to sustainable development. Evidence suggests that disaster risks are rising at a rate that significantly outstrips progress in building resilience. Disasters exacerbate inequity because they have a greater impact on vulnerable groups, which can in turn exacerbate fragility and conflict.

In order to develop safer construction solutions, it is necessary to understand the different hazards that affect the country. Hazards affect lives and development. By analysing the different hazards and considering them in relation to the built environment, public authorities, communities, and citizens can effectively reduce the risk of disasters.

The purpose of this chapter is to develop an awareness of which natural hazards which should be considered in the implementation of school infrastructure. It contains preliminary hazard related information only. Future versions of the SSCG will include hazard zonation maps and tables identifying qualitative hazard levels for the predominant hazards in Malami.

It is very important that each hazard described in this chapter is not considered in isolation, but as part of a holistic review of all the hazards which may impact on school safety. A safer school is able to adapt to the different risks and resist different hazards that might occur frequently or occasionally in that location.

Information on hazards helps communities, relevant authorities and other stakeholders to:

a. Be aware of the different hazards occurring in the area;

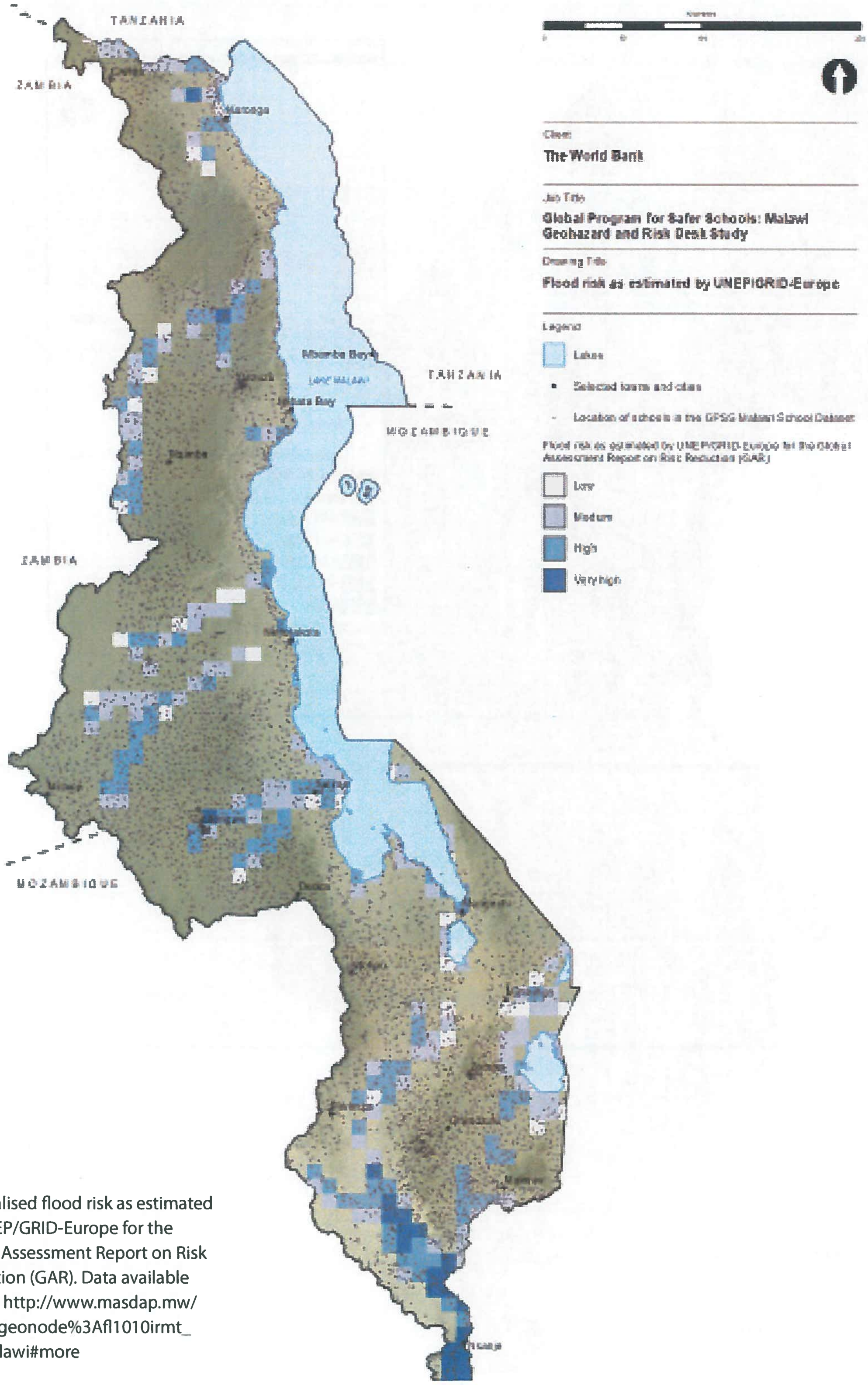
b. Identify the most suitable areas for development purposes;

c. Develop the best construction solutions in order to mitigate the risks and possible losses;

d. Determine the best options in order to deal with the different possible risks;

The World Bank have developed an online tool, ThinkHazard!, which provides a general overview of the hazards for a given country which might be considered during project implementation and design to promote disaster and climate resilience. ThinkHazard! provides a qualitative appraisal of the likelihood of a given country, or part of a country, to experience a given natural hazard. These hazard levels are based on published hazard data provided by a range of private, academic and public organizations. Table 1 summarises the ThinkHazard! hazard levels for Malawi for the main hazards related to the built environment:

HAZARD	THINKHAZARD! HAZARD LEVEL
Flooding	High
Cyclone	Medium
Earthquake	Medium
Landslide	Low
Wildfire	High



Generalised flood risk as estimated by UNEP/GRID-Europe for the Global Assessment Report on Risk Reduction (GAR). Data available online: http://www.masdap.mw/layers/geonode%3Afl1010irmt_clipmalawi#more

Strong Winds/Cyclones

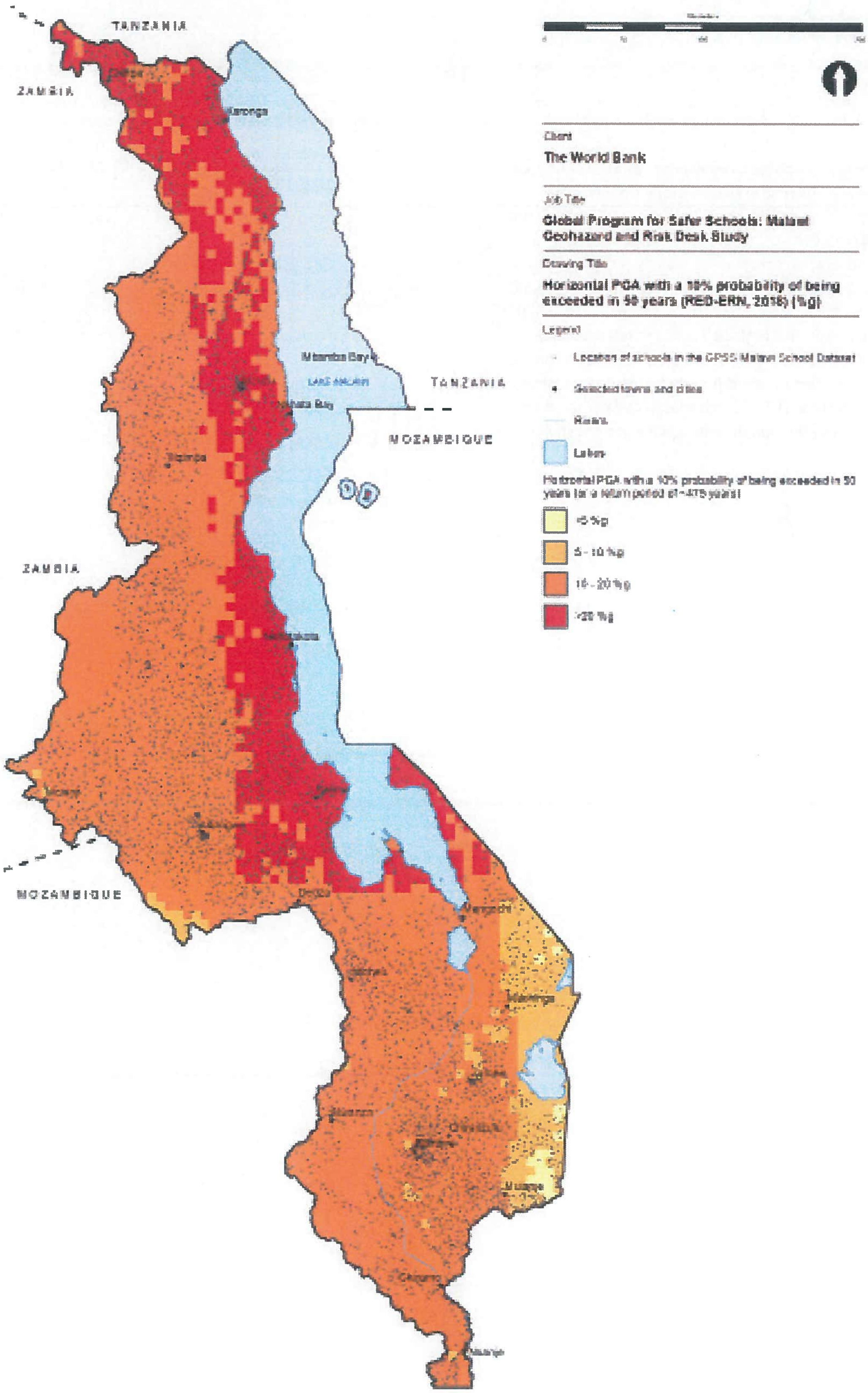
Strong winds and occasionally cyclones affect the entire country of Malawi, with severe consequences for buildings and their occupants. As noted by the "Disaster Risk Management Handbook", by DODMA, "A storm is a violent weather condition with winds of 24.5 m/s (89 km/h – 6 Beaufort scale) and usually accompanied by precipitation, thunder and lightning. Strong winds are sustained winds of 24.5 m/s or greater speed"[1].

Strong winds are usually intensified by:

a. Deforestation;

b. Topographic conditions (i.e. where the topography creates concentrated wind effects or "wind tunnels")

(1) Department of Disaster Management Affairs, "Disaster Risk Management Handbook, A Handbook for practitioners, communities, educators and learners in Malawi", 2013, pag.58


TANZANIA
ZAMBIA
Karonga
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MOZAMBIQUE
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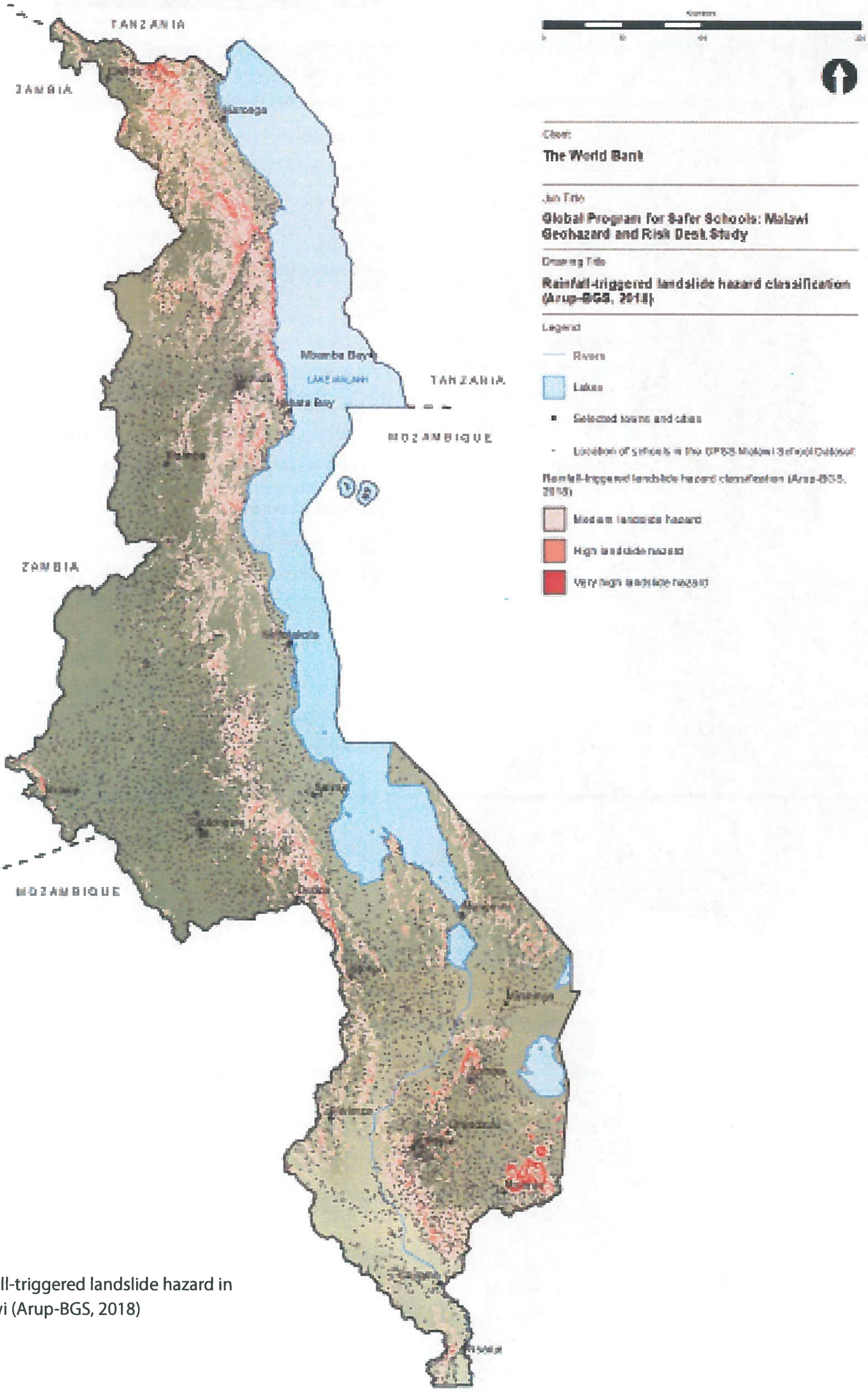
Client
The World Bank
Legend
Lakes



Rainfall-triggered landslide hazard in Malawi (Arup-BGS, 2018)

Wildfires/ Fires

Wildfire hazard is classified as High by ThinkHazard! throughout Malawi. This means that there is a greater than 50% chance of encountering weather which could support a significant wildfire which is likely to result in both life and property loss in any given year.

Fire-related hazards can either be true "wild fires", in that they originate through natural processes, or can be man-made in origin, resulting typically from negligence, poorly managed slash-and-burn agricultural practices, arson (e.g. IOL, 2005), or often in parts of the developing world, inadequate or illegal electrical networks.

The choice of the construction site is probably the most important factor that affects the building's safety. The site selection should take into consideration all the different hazards that are prevalent in Malawi. For this reason, the construction process should not only consider the hazard deemed most typical for the area but should consider all other possible hazards that could occur during the building's life-span.

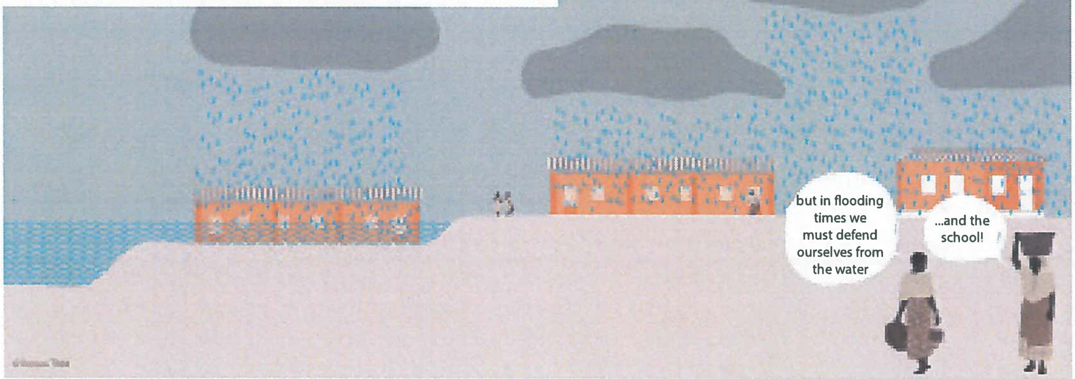
Local knowledge, historical data, information provided by local authorities, and relevant stakeholders should all be considered when selecting a safe site for a school. It is clear that local communities play a key role in the selection of sites for school buildings. As such, it is important that the relevant authorities work closely with the local communities to ensure they are aware of the prevalent hazards and other site selection considerations during this process.

Also, important when considering a site are factors such as compliance with the National Norm Guidance for School Construction of Malawi, the preparation of the Environmental and Social Impact Assessment, and accessibility in a post-disaster environment.

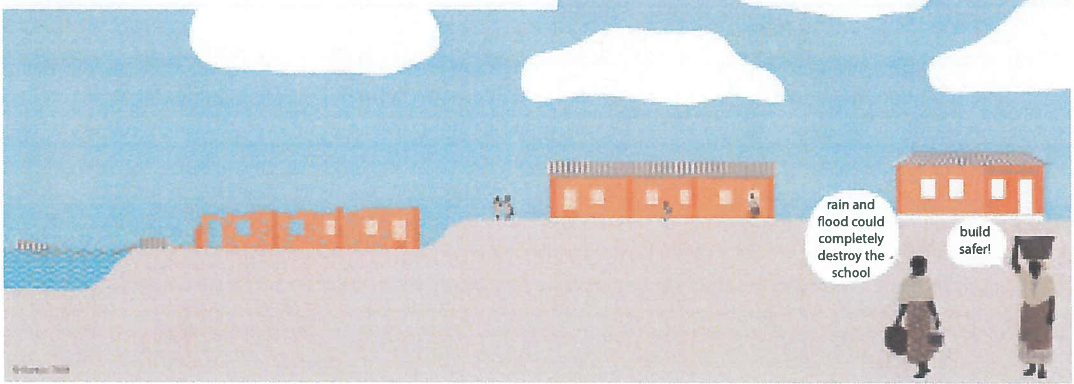
This chapter will look at the various factors that could affect the suitability of a site. It is important to note that it may not be possible to satisfy all the guidance when selecting a site. In these cases, those involved in the decision shall take a balanced view of the risks associated with a particular site and subsequently identify suitable mitigation measures, where it is not possible to avoid all relevant hazards.

It is unsafe to build the school in areas prone to flooding

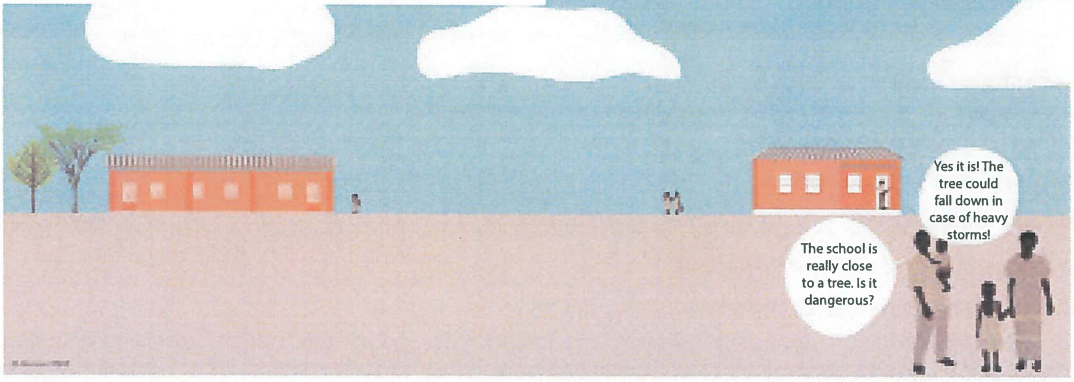
During the rainy season or in case of flood, water can reach the school



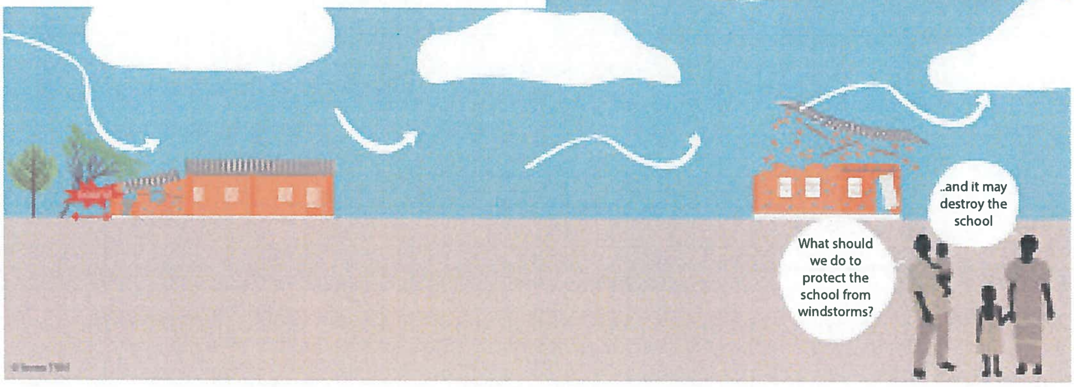
Build your school at a minimum distance of 50m from the river / raise floor level



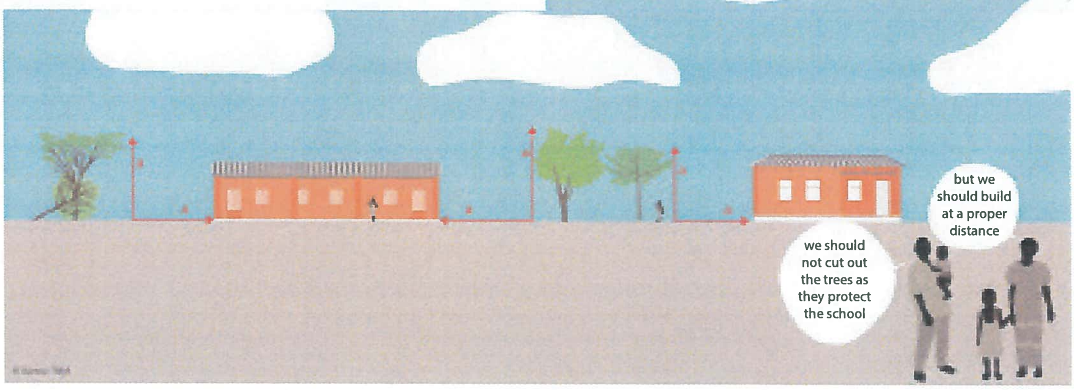
Do not build your school under a tree, as it may fall down



In case of strong winds



Build your school at a proper distance from the trees

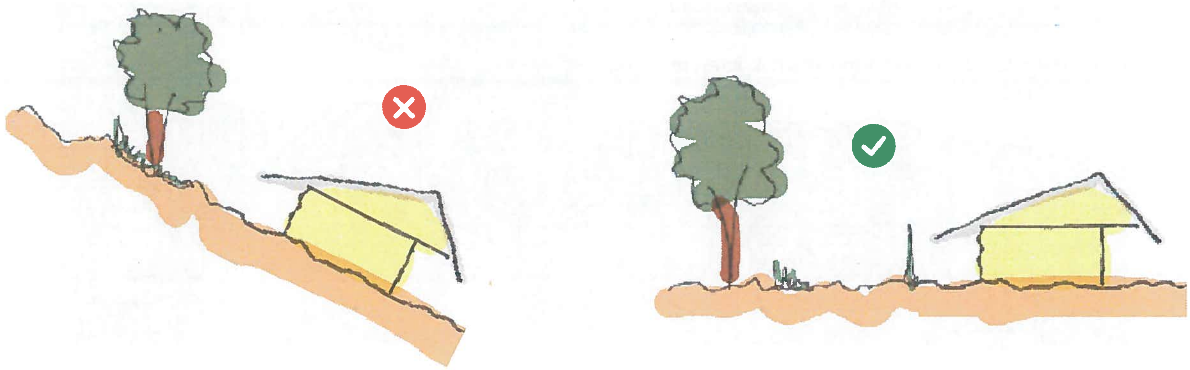


Landslides

Parts of Malawi are particularly susceptible to landslides due to a combination of factors including tropical cyclones, deforestation and ground conditions.

To respond to the risk of landslides it is recommended to:

- Choose a site away from escarpments
    - Do not choose a site against, or on top of retaining walls of a slope
    - Choose sites between retaining walls of a slope, where relevant
- Evaluate the slope conditions: if the slope is steeper than 1 in 1.7 with no drainage systems, no soil stabilisation through vegetation, no proper retaining walls, and with poor soil conditions, it is not recommended to choose a site at the top or bottom of the slope
- Choose a site remote from the base of the slope
- Choose a site without deep cuts into a hill or slope



- Choose a site with relatively stiff and compact soil. Avoid sites with uncompacted fill material

Wildfires & Fires

Fire-related hazards can either be through wildfires, in that they originate through natural processes, or can be man-made in origin, resulting typically from negligence, poorly managed slash-and-burn agricultural practices, arson, or often inadequate/illegal electrical networks.

To respond to the risk of wildfires it is recommended to:

- Define the appropriate safety distance from forests to protect against wildfires
- Ensure the site is large enough to allow safe distance between buildings
- Verify the status of existing electrical devices and do not build close to power lines

Other Considerations

- Check if the land requirements of the National Norm Guidance for School Construction of Malawi are satisfied:
  - Location: central to the catchment area with good access, suitable for construction
  - Land for the school buildings: min. 1 Ha for an 8-classroom school, 1.5Ha for a 16-classroom school.
  - Land for teacher accommodation: min. 1/20 Ha. Per house
  - Land for sports grounds: min. 1 Ha. or access to existing grounds within 200m (approx. 3 min walk)
- Choose sites and access routes which have the necessary permissions from owners and other stakeholders
- Try to select sites that do not require clearing or levelling that would add to the cost and construction time
- Choose a site with exterior lighting, passive surveillance (i.e. can be overlooked by the community) and has safe access routes e.g. opt for a site near villages (neighbourhoods as natural guardians)
- Select a site closer to the most populated catchment area
  - E.g. a school serving two villages, should be closer to the most populated one
- Prefer a site located near other community services (better for children and parents' access)
- Choose a site far from industrial activities, rubbish heaps or other toxic waste sites
  - (E.g. settle away from elements which could turn dangerous in case of hazards)
- Ensure the presence of shaded areas for school occupants

Future revisions of the SSCG should include preparation of user-friendly guidance to aid users consider all relevant aspects of site selection. It is assumed that this will predominantly be used by local communities/contractors and must be written appropriately. Site appraisal should be carried out to identify key risks and where mitigation measures may be necessary to reduce exposure of hazards to acceptable levels.

Further advances in this area could also involve development of a decision-making tool and checklists for central/local authorities who are responsible for approving site selection.

Site Investigation

Once a suitable, hazard-responsive site is selected, it is important to assess the ground conditions to inform the design of the foundations and if any additional steps need to be taken to ensure the safety and durability of the buildings.

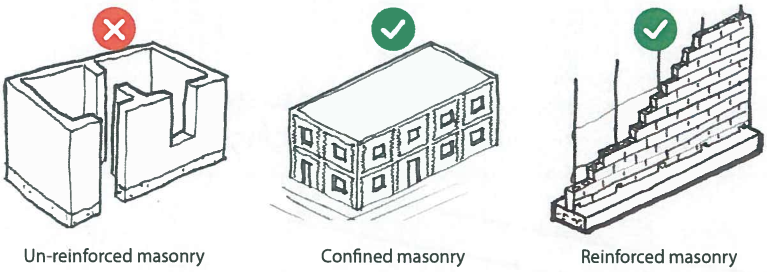
The key aspects to be undertaken during a site investigation are as follows:

1. Ground Investigation – to include trial pit excavation, strength testing and soil sampling for classification testing and hand augering to identify presence of groundwater
2. Soil shrinkage test
3. Infiltration test
4. Topographical survey

Future revisions of the SSCG will provide guidance for each of these aspects.

CHAPTER 5

Model School Construction Drawings and Details

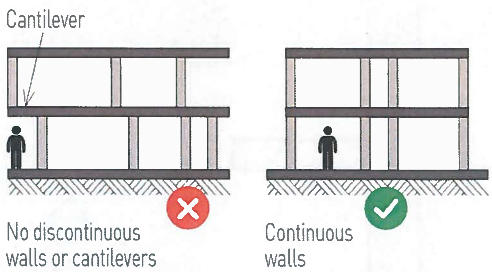


All masonry walls should be reinforced with bars running vertically and horizontally.

Alternatively masonry may be confined by RC tie beams and columns.

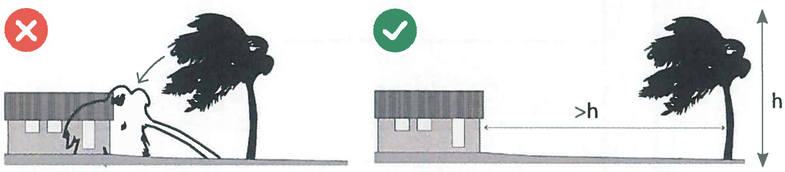
Un-reinforced masonry is not allowed.

Refer to construction details to reduce the risk of damage during an earthquake or high winds. The key principle is to properly tie all the structural elements together.

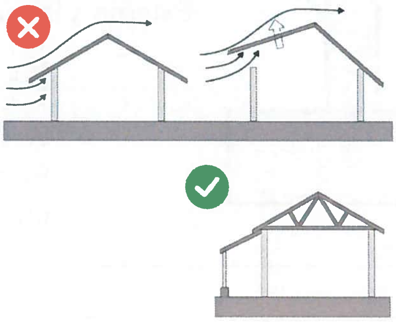


Walls and columns should be the same size and continue from roof level to foundation level in a straight line. Cantilevers should be avoided. Any building raised on stilts to avoid flooding should be designed by a professionally qualified engineer to ensure that the frame is capable of resisting earthquake loads without collapsing.

Strong Winds / Cyclones



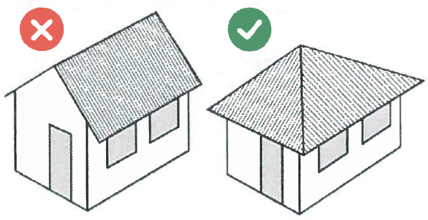
Locate the building far enough away from trees and other things that could fall onto the building.



A roof overhang more than 400mm should be designed by a professionally qualified engineer to prevent uplift in strong winds.

Roofing sheets should be well connected to the roof structure, ideally by using J-hooks or roofing screws.

Verandas or open sided roof extensions should have a separate roof structure to avoid damage to the main roof.



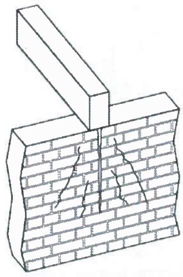
Roof shape - Hipped roofs perform better than gable ends. By reducing the height of the walls the lateral loading from wind and earthquakes is reduced.

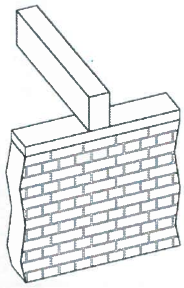
Recurrent deficiencies

The following deficiencies have been found to occur on regular basis in school buildings in Malawi. These deficiencies have been used to inform the construction details in the SSCG.

Concentrated roof load on poor masonry

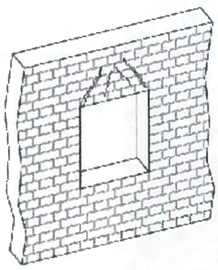
Wrong detail: Timber beam is located directly on brick wall. The load is transferred on narrow surface. Therefore, the compressive stress on masonry are too high and a crack is likely to form.

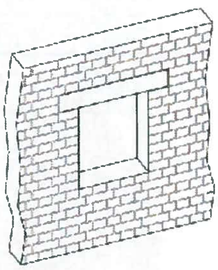




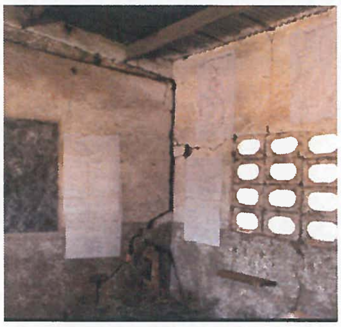
Weak openings

Wrong detail: Absence of intel and rigid window (door) frame is the reason of the development of cracks in the masonry.

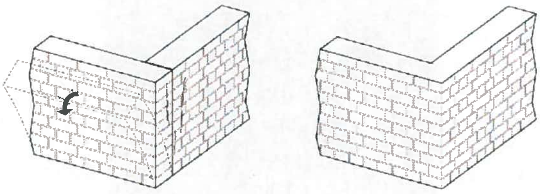




Out-of-plane failure of wall panels

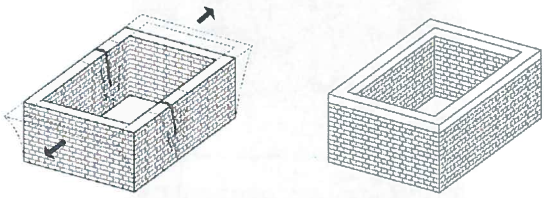


Wrong detail: Absence of tooting between perpendicular walls, absence of top ring beam. Every wall behaves as a vertical cantilever, prone to out-of-plane failure.



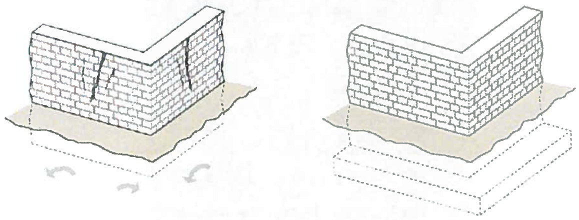
Absence of top ring beam + weak foundation

Wrong detail: Absence of top ring beam together with poor shallow foundations prevent a proper box-like behaviour of the masonry structure. Cracks are likely to open due to the impossibility of facing differential settlements.



Foundations

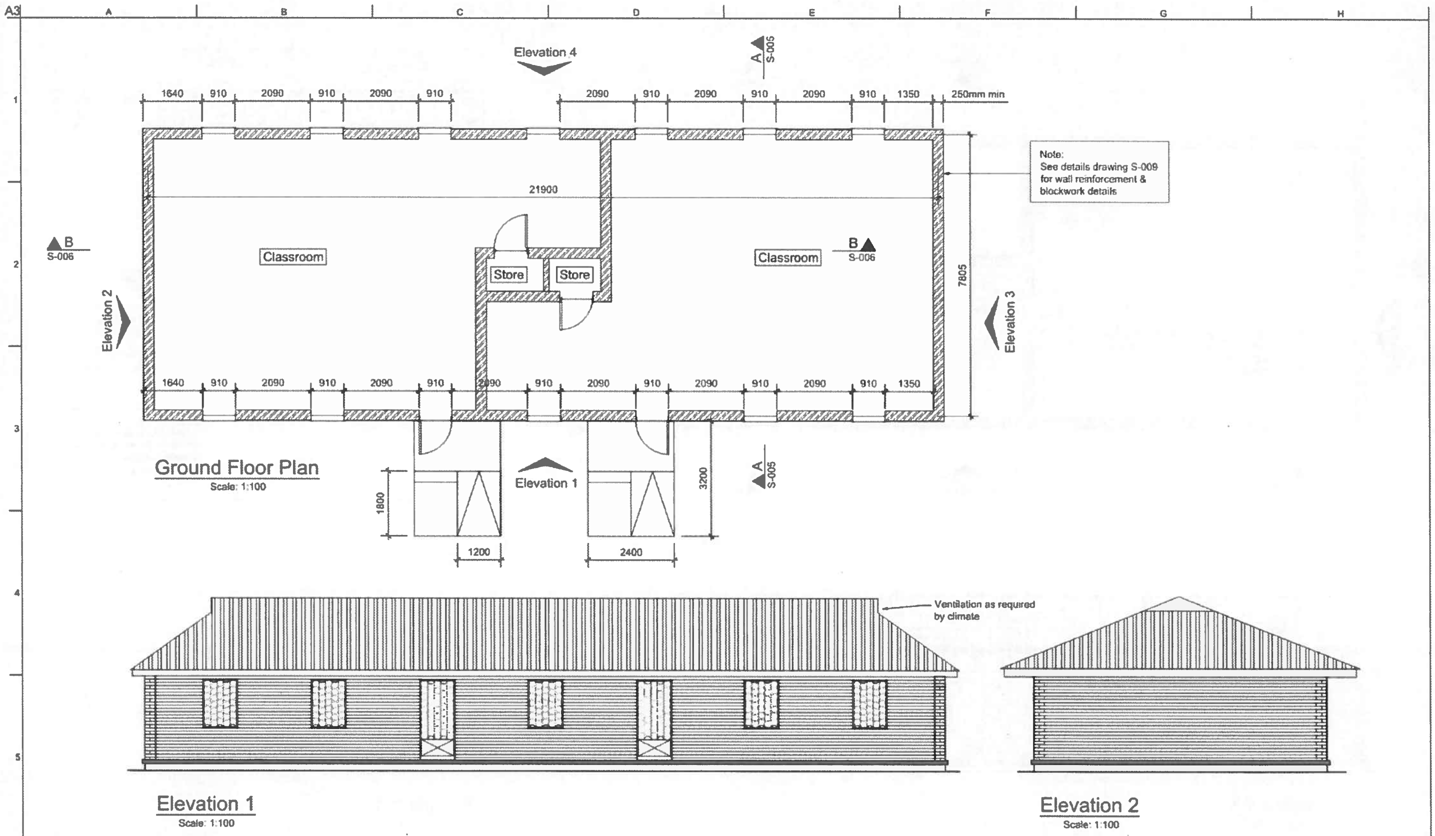
Wrong detail: Poor shallow foundations on weak soil cause differential settlements which induce the development of a wide severe crack pattern all over the masonry superstructure.



Model School Design Drawings

These drawings are based upon an EIMU model design which has been updated, in particular to account for seismic hazard in Malawi.

It makes provision for use of either SSBs or Concrete blocks and assumes steel roof truss construction. All masonry is reinforced with steel rebar, as explained in earlier sections.



Material Specifications
SSBs to be $5N/mm^2$ min. compressive strength. Concrete blocks to be $5N/mm^2$ min. compressive strength. Mortar strength to be min. $5N/mm^2$. Reinforcement to be high strength ($500N/m^2$) with ribs. Concrete to be class C20/25. Concrete must be vibrated after placement. Steel to be grade S275. Refer to materials chapter of specification for further details

V1	14/12/18	VB	TW	AM
Issue	Date	By	Chkd	Appd

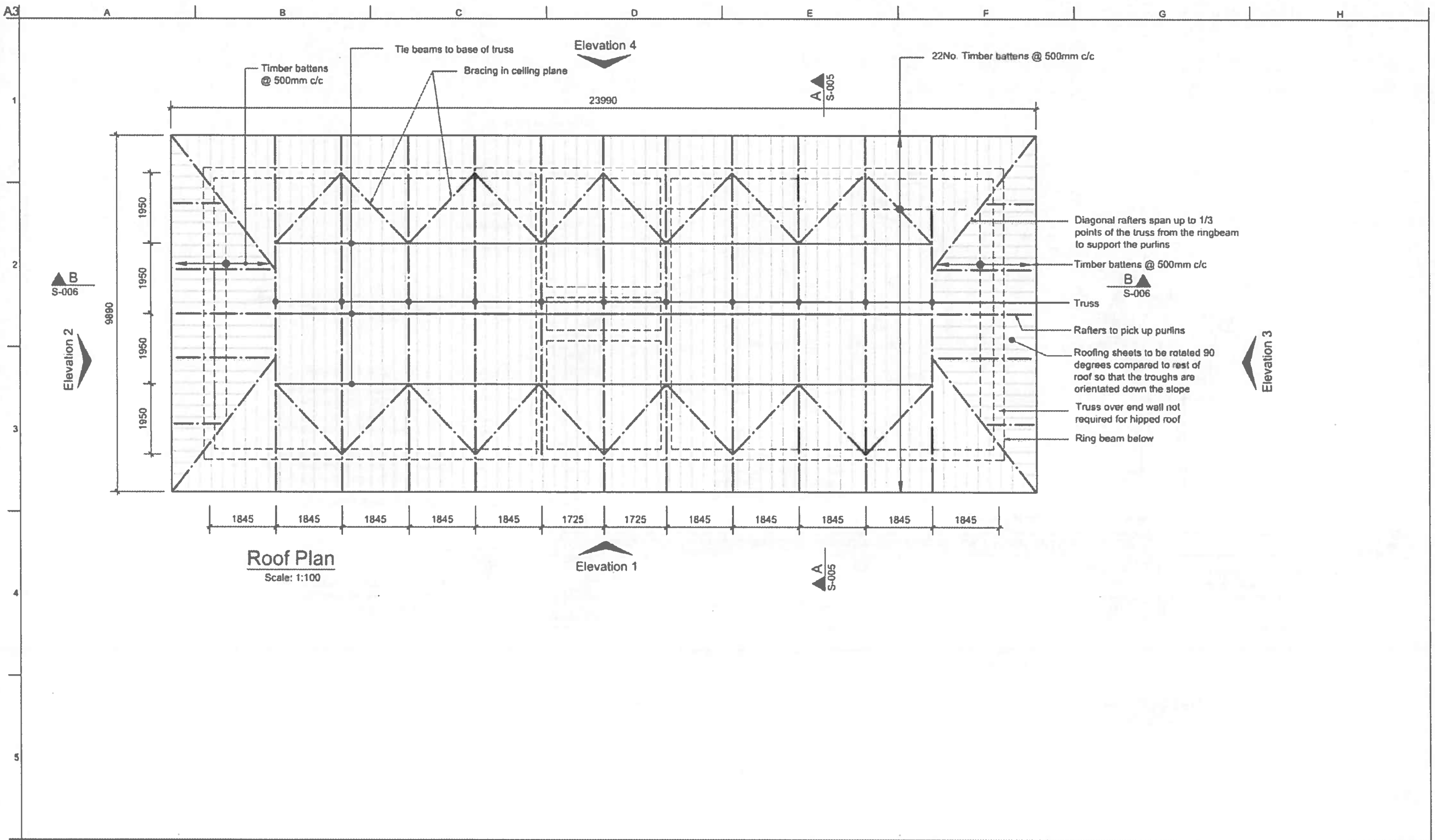
Job Title
Malawi Safer School Construction Guidelines

Client
Ministry of Education Science & Technology, Malawi

Drawing Title
Combined Standard Classroom Ground Floor Plan & Details

Scale at A3: 1:100
Discipline: Structural
Job No: 247006-04
Drawing Status: Issue 1
Drawing No: S-002
Issue: V1

Do not scale



V1	14/12/18	VB	TW	AM
Issue	Date	By	Chkd	Appd

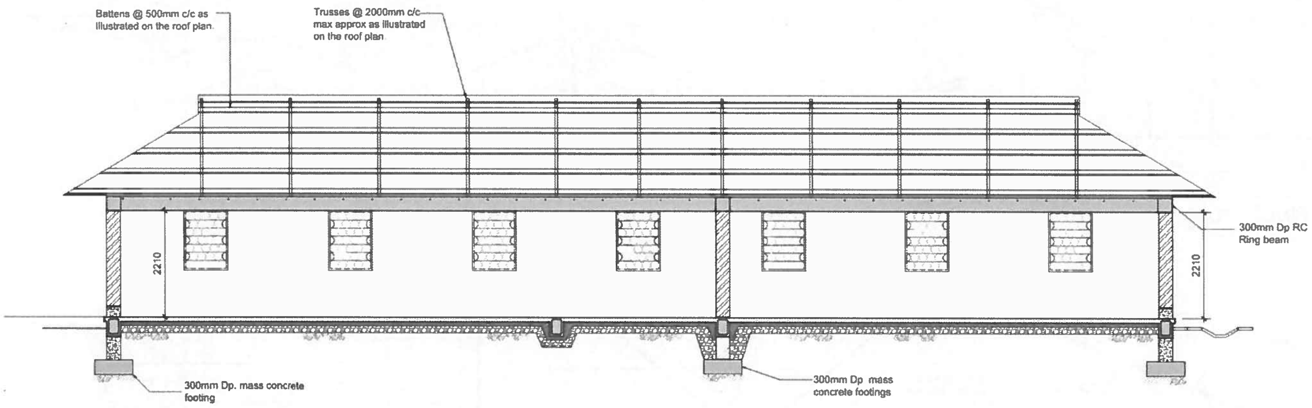
Job Title
Malawi Safer School Construction Guidelines

Client
Ministry of Education Science & Technology, Malawi

Drawing Title
Combined Standard Classroom Roof Plan

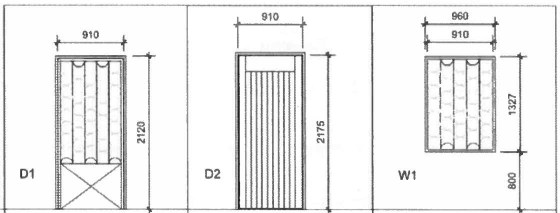
Scale at A3: 1:100
Discipline: Structural
Job No: 247006-04
Drawing Status: Issue 1
Drawing No: S-004
Issue: V1

Do not scale

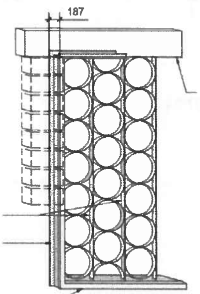


Section B-B

Scale: 1:75

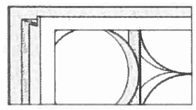


	D1	D2	W1
LOCATION	Classroom (external)	Classroom (store room)	Classroom
FRAME TYPE	Mild steel section	TBC	Proprietary metal frame & cill
FRAME DECORATION	Red oxide & 2 coats enamel	TBC	Red oxide & 2 coats enamel
DOOR TYPE	Metal grille door	TBC	n/a
STAY	Proprietary tower bolt	TBC	n/a
QUANTITY	1 per classroom	1 per classroom	6 per classroom



Part Window 3d View

Scale 1:50



Part Window Corner Detail

Scale: NTS

Issue	Date	By	Chkd	Appd
V1	14/12/18	VB	TW	AM

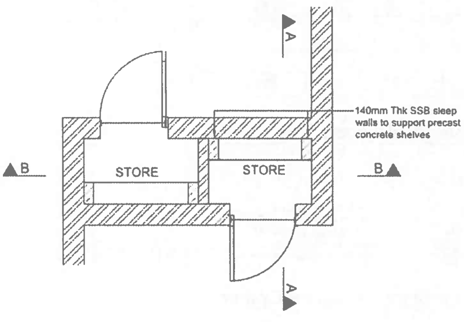
Job Title: Malawi Safer School Construction Guidelines

Client: Ministry of Education Science & Technology, Malawi

Drawing Title: Combined Standard Classroom Section B-B & Window/Door Schedule

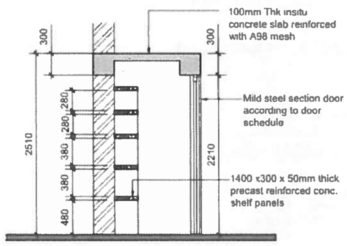
Scale at A3: as shown
Discipline: Structural
Job No: 247006-04
Drawing Status: Issue 1
Drawing No: S-006
Issue: V1

Do not scale



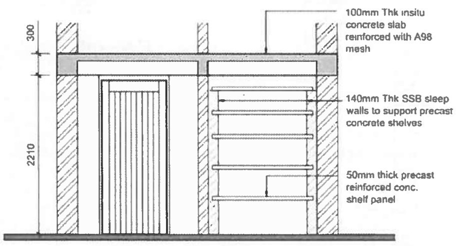
Store Room Plan

Scale: 1:50



Section A-A

Scale: 1:50



Section B-B

Scale: 1:50

V1	14/12/18	VB	TW	AM
Issue	Date	By	Chkd	Appd

Job Title
Malawi Safer School Construction Guidelines

Client
Ministry of Education Science & Technology, Malawi

Drawing Title
Combined Standard Classroom Store Room Details

Scale at A3: 1:50
Discipline: Structural
Job No: 247006-04
Drawing Status: Issue 1
Drawing No: S-008
Issue: V1

Do not scale

CHAPTER 6

Construction Materials and Workmanship

Substructure

FOUNDATIONS

The aim of the foundations is to transfer the weight of the building into the ground by ensuring that the contact pressure does not exceed the soil strength and by avoiding the occurrence of differential settlements or, at least, by limiting their magnitude.

Depending on the kind of soil on site, an appropriate technological solution should be adopted and, if not possible, the location of the building should be changed to a site with a foundation soil with better properties.

SOILS TO AVOID

Building on the following should be avoided:

- Black cotton soil
- Soils with ground water level above the underside of the foundation. Beware that the water table may vary between dry and wet seasons. If in doubt check with local people. You may use the depth of water in a well as a reference point or else dig a trial pit.
- Loose sand, peat, soft silt and poorly compacted clays as they may undergo large settlements during an earthquake.
- Backfill material as the weight of the building can cause large differential settlements.

FOUNDATION DEPTH

- The founding level should be free of organic material (dig down below topsoil)
- The foundation depth will depend on the type and the quality of the soil. You must dig down until you reach soil which has sufficient strength to support foundations. If in doubt a minimum value of 1m should be used, although in some cases it ma be necessary to dig deeper. Refer to tables across which give guidance for both cohesive and non-coheisve soils.

Soil	Identification Test	Interpretation
Very loose	Crumbles very easily when scraped with pick.	Too weak to support foundations.
Loose	Small resistance to penetration by sharp end of pick.	Sufficient strength to support foundations.
Medium dense	Considerable resistance to penetration by sharp end of pick.	Sufficient strength to support foundations.
Dense	Very high resistance to penetration of sharp end of pick; requires many blows of pick for excavation.	Sufficient strength to support foundations.
Very dense	High resistance to repeated blows of pick; requires power tools for excavation.	Sufficient strength to support foundations. Requires power tools for excavation.

Low tech tests to determine strength of granular soils (sands an gravels)

Soil	Identification Test	Interpretation
Very soft	Pick head can easily be pushed in to the shaft of handle; easily moulded by fingers.	Too weak to support foundations.
Soft	Easily penetrated by thumb; sharp end of pick can be pushed in 30 – 40 mm; moulded with some pressure.	Too weak to support foundations.
Firm	Indented by thumb with effort; sharp end of pick can be pushed in up to 10 mm; very difficult to mould with fingers; can just be penetrated with an ordinary hand spade.	Sufficient strength to support foundations.
Stiff	Penetrated by thumb nail; slight indentation produced by pushing pick point into soil; cannot be moulded by fingers; requires hand pick for excavation.	Sufficient strength to support foundations.
Very stiff	Indented by thumb nail with difficulty; slight indentation produced by blow of pick point; requires power tools for excavation.	Sufficient strength to support foundations. Requires power tools for excavation.

Low tech tests to determine strength of cohesive soils (clays)

Masonry - Stablised Soil Blocks (SSBs)

NOTE: ALL MASONRY MUST HAVE A COMPRESSIVE STRENGTH > 5N/mm^2

KEY POINTS

Stabilised soil blocks are where portland cement is added to soil to improve the strength and durability of the blocks. In the case that the blocks are compressed in a machine this will increase their density and further improve their properties.

If made correctly SSB's can make strong and durable blocks. If made incorrectly they can quickly deterioriate, especially in the presence of water. This chapter describes how to make good quality SSB's on site:

1. Test the soil to check it is suitable. Not all soil is suitable.
2. Use the right mix of soil, cement and water
3. Make sure you manufacture and cure the blocks carefully
4. Test the finished blocks to check their quality

If the site soil is not suitable use concrete blocks. Alternatively it may be possible to buy ready made SSBs from a factory such as Lafarge 14 trees in Lilongwe. This has the advantage that the blocks come with a quality certificate.

Refer to MS 777-2007 for further details.

SOIL SELECTION

Soil is made up of gravels, sands, silts and clays. Differnt soils have different proportions of each giving different properties and behaviour overall as a result.

Gravel	Sand	Silt	Clay
>2mm	2mm - 0.063mm	0.063mm - 0.002mm	< 0.002mm
			

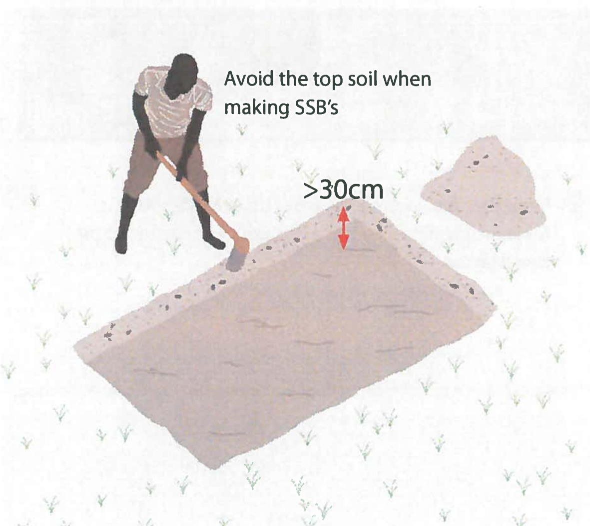
Gravel and sand do not expand or shrink when in contact with water or moisture where as silt and clay do, causing them to change volume. Clay can also display varying levels of cohesion, which can be of benefit in block production.

The manufacture of good quality and durable soil blocks requires the appropriate choice of soil. Topsoil and vegetal soil, which contain a high proportion of organic matter must be discarded. Soil for building purposes is generally found below 30cm deep, although it is still necessary to verify the absence of organic matter.

A good soil suitable for soil bricks should contain:

- fine gravels and sand: 50 - 75%
- clay and silt: 25 - 35%

Guidance on testing to determine suitability of soil for making blocks is given on the next page



SSB MANUFACTURE

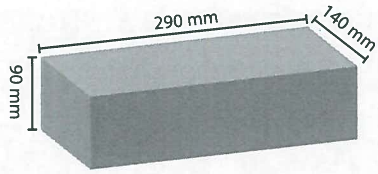
SSBs are soil blocks stabilised through:

- mechanical compaction at optimum moisture content;
- addition of a low amount of ordinary Portland cement.

The higher density obtained through compaction significantly increases the compressive strength of the blocks, as well as their resistance to erosion.

Adding cement before compaction causes considerable improvements that include the reduction of the shrinkage/ swelling effect (directly related to waterproofing), and the increase in density, strength and durability. Due to the presence of cement, termites do not represent an hazard for SSBs.

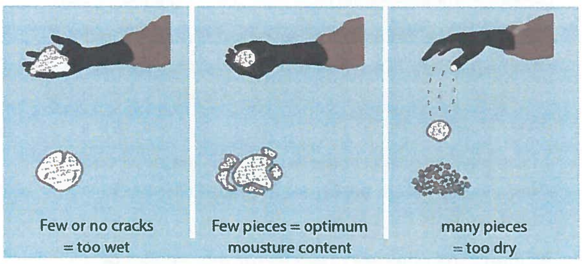
Walls must be at least 250m thick. Walls can be made of a single block that is 250mm thick, or of two blocks that are at least 120m thick, such as the example of a tyical SSB brick below:



The process for manufacturing SSBs is:

1. Identify an appropriate soil. Use the linear shrinkage test to determine how much cement should be used.
2. Dry the soil. Crush the soil to break down larger lumps. Sieve the soil to remove stones that are larger than 6mm and any remaining roots. Large stones cannot bond properly with the earth and cement and create a weakness in the block which could cause it to crack and fail. A large sieve can be made by overlapping 12mm metal mesh and attaching it to a wooden frame.

3. Mix the cement and soil in the correct proportions. Only mix 10 buckets at a time as it is easier to mix the cement evenly in a smaller batch. The mix should be an even colour. Do not use a concrete mixer as the soil will stick to the sides and not mix properly.
4. Water should be mixed in gradually and thoroughly by hand. Mixing time should be at least 8 minutes in total.
5. To check the water content, a small ball of mixture about 40mm in diameter should be dropped from shoulder height onto a flat hard surface. If it crumbles, it is too dry. If it remains in one piece it is too wet. If it breaks into two or three pieces it has the correct water content.



SSB BLOCK TESTING

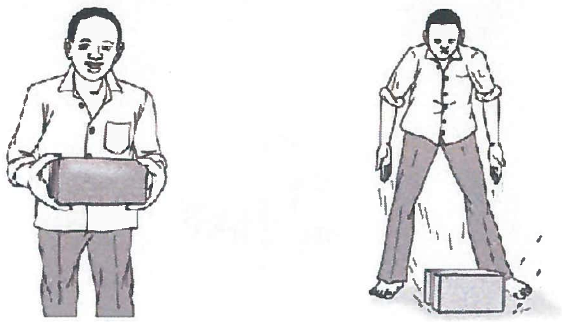
Lab tests

Where available the following lab tests should be conducted to appropriate local standards:

Dry compressive strength >5N/mm^2

Site Tests

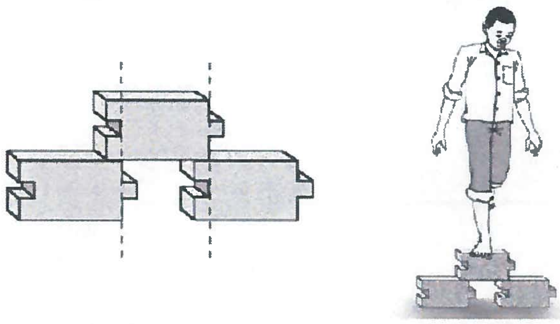
In the absence of lab tests the following site tests may give an idea of block quality and can be conducted cheaply and quickly.



Drop test

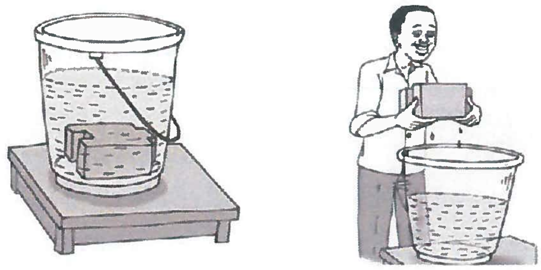
The drop test checks the block strength. A block should be dropped from a height of 1 metre. Good blocks do not break, except at the edges.

To check that blocks are strong enough to use in the building there are tests that can be carried out on site.



Bending test

The block bending test checks the bending strength of the block. Place blocks as shown below and stand on the top block with a full body weight at the centre. Good blocks will not break.



Water immersion test

The water immersion test checks the durability of the block to cycle of wet and dry weather. Place 5 fully cured blocks into water overnight so they are completely covered. Leave them in the water for at least 12 hours overnight. Take them out and let them dry in the sun for the day. Repeat this process every day for 7 days. If the block falls apart, cracks or bits flake off there is something wrong. It might be that the mix is wrong or the soil is not good for SSBs.

Image copyright (c) T4T. Interlocking stabilised soil block: machine operation manual

Masonry - Concrete Blocks

NOTE: ALL MASONRY MUST HAVE A COMPRESSIVE STRENGTH > 5N/MM^2

Concrete blocks are made from a mixture of small aggregate, sand and cement. Block quality is dictated by materials, mix, cement content, manufacturing process and curing.

Concrete blocks can be bought from a block supplier or made on site. If they are being purchased, there should be a visit to the supplier to inspect the process and to test the block strength.

A mix of 1 part cement to 7 parts sand and aggregate should be used if producing blocks on site.

Washed aggregate of less than 10mm in diameter should be used. Aggregates of various types can be used, but crushed rock (which is angular with a variety of grain sizes) gives best results.

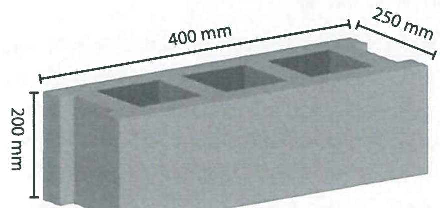
A concrete mixer should be used in block production. The concrete should be mixed until a uniform colour.

Mechanical compaction is recommended with a vibration of 4 to 5 seconds minimum. If compacting manually, ensure all faces are not excessively porous and have a similar smoothness throughout.

Blocks should be wet cured for 7 days by watering twice a day and storing under plastic sheets. They should then bestored for another 10 days in the shade before use. consistently provides good results in compressive strength.

Cutting a concrete block weakens it by removing the end wall. Where it is required to cut blocks the cut block must be filled with grout.

Refer to MS 71-2000 for further details



The size of a concrete block should be 400 mm long by 250 mm wide by 200 mm high.
No more than 25% of the volume should be voids.

A rough finish at the top and sides of the block (right) is and indication of insufficient general compaction.

A smooth and regular finish on the top and sides shows good compaction throughout the black

Image credit © Build Change

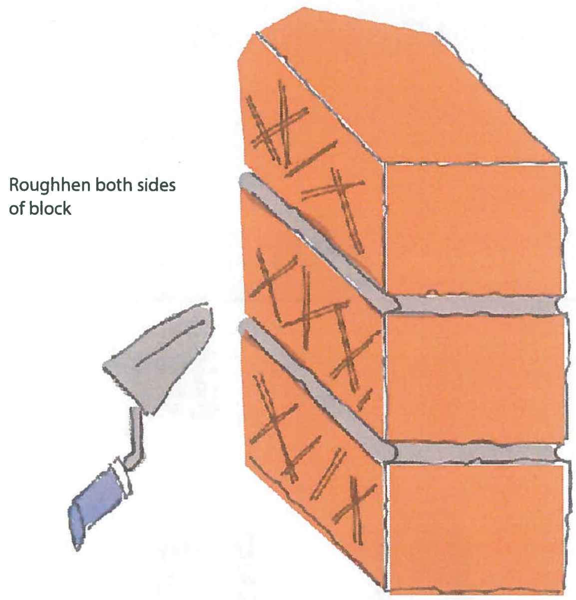
Masonry - Plaster

The plaster is there to protect the masonry. Rain and sun will gradually damage the plaster. When this happens the plaster should then be repaired.

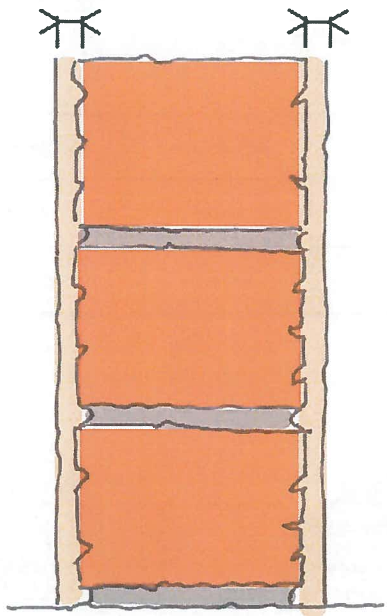
A sand-cement plaster should be used. This should have a cement: sand ratio of 1:6.

PLASTER APPLICATION

1. When laying the soil blocks the mortar joints should NOT bemade flush with the blocks. This will help the plaster to stick to the wall.
2. For SSB's roughen the surface of the wall with a sharp tool. Creating marks in the wall will again help the plaster to stick.
3. Clean any loose dirt from the wall.
4. Pour water onto the surface of the wall with a watering can or similar immediately before applying the plaster. Wetting the surface of the wall helps to prevent the plaster from drying out too quickly and can help stop cracks.
5. The plaster should be applied to the wall as quickly as possible.The mason must work quickly to make the plaster smooth. Once the plaster is smooth the mason must STOP trowelling and move to a new section of the wall. Trowelling the plaster repeatedly sucks water from inside the plaster on to the surface where it evaporates. This makes the plaster crack.
6. Once applied the render should be kept in the shade to protect it from the sun. The render should be kept wet



Mortar joints are not smooth



Rough surface helps render to stick

Quarry dust

River sand can be used for concrete but must be sieved to remove plant roots

Sieve sand to remove plant roots

CONCRETE MIXING

The mix ratios for concrete are as follows:

	Portland cement	Sand	Aggregate
Structural Concrete	1	2	4
Mass Concrete	1	4	8
Blinding	1	4	8
Mortar	1	4	-
Pathways	1	6 2	6

Concrete should be mixed using a mechanical mixer where ever posible. This ensures consistency and avoids weak batches.

The same bucket should be used for each material and it should be level filled, not heaped. Cement and aggregates should be thoroughly mixed together first before gradually adding water to the mix. Concrete is to be mixed continuously until poured.

If mixing several batches in a row, you can track the mix count by marking with a piece of chalk on the mixer or by placing stones in cups.

It can be tempting to add more water to make the concrete more workable. This will make weaker concrete. Water content should be checked with a slump test (see next page).

If hand mixing for concrete is the only option, extra care must be taken with the mixing process.

- One person should oversee hand mixing throughout whilst mixers and pourers should be rotated to avoid fatigue in the mixers, which could reduce the mix quality.
- Mix on a hard, flat, clean surface. The first batch of concrete could be used to cast a mixing surface for future batches.
- Cement and aggregate should be mixed thoroughly first to a uniform colour before adding water.
- Concrete should be mixed for at least 5 minutes by turning several times. The mix should be a uniform colour and consistency.
- Hand mixing with a correct water:cement ratio is hard and it is common for the mix to feel too dry and for workers to add more water. This should be avoided. The quantity of water should be enough to make a soft ball of the mixed concrete in hand.

A slightly wetter mix is better for hand compaction, whereas a drier mix is preferable when a mechanical vibrator is used for compaction.

PLACING CONCRETE

If wheelbarrows are used, make sure that timber runways do not damage reinforcement.

Concrete should be placed in the formwork as close as possible to its final position rather than moved around excessively.

Mixed concrete should not be allowed to stay on the platform for more than 45 minutes and must be placed in the forms and compacted continually. Concrete should normally be cast in a single, continuous operation.

If a single pour is not possible, workers need to be aware of where the end of the day's pour should reach to avoid cold joints in adverse locations. Cold joints are joints within elements where the concrete has gone off before the next concrete is placed. When a pour must continue from a cold joint the connecting surface should be 'scabbled' to promote maximum bonding between new and old concrete. 'Scabbling' involves breaking back the concrete surface to expose the aggregate and give a jagged edge. Ensure that dust and loose material are cleaned from the surface before pouring.

De-bonding agents such as wax, diesel, used engine oil, used cooking oil and palm oil could be used on formwork. Diesel and used engine oil are not recommended due to the difficulty of disposing of them in an environmentally friendly manner.

CONCRETE COMPACTION

Compacting the concrete properly is very important. When concrete is poured, air bubbles can become trapped inside. If the air bubbles are still trapped in the concrete when it hardens then the concrete will be made weaker. Compacting the concrete removes the air bubbles and helps make the concrete strong.

If a poker vibrator is available insert close to full depth for 15 seconds at intervals of 150-200mm. If a poker vibrator is not available, hand compaction can be achieved using steel rods and timber sticks. All concrete should be thoroughly compacted.

Care should be taken not to damage the reinforcement. Pay particular attention to compacting the concrete into corners, especially if there is reinforcement in the way.

Timber

TIMBER SELECTION

Timber is assumed to be Pine.

When selecting timber for structural use, the following aspects should be observed:

- accuracy of section dimensions;
- straightness and absence of twist;
- absence of cracks and splits;
- absence of large knots on the outer edges of the timber is preferable. If knots are present, then ensure they are on the load side;
- grain along the length of the timber and not to the side.

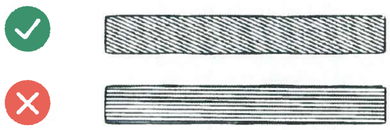
Take extra care when selecting timber for primary elements such as trusses and columns, compared to, say purlins.

When purchasing timber try and ensure that it is relatively dry (to limit shrinkage in service) and has been stored under cover from rain and sun. Continue to store timber under cover in neat stacks to prevent warping once on site.

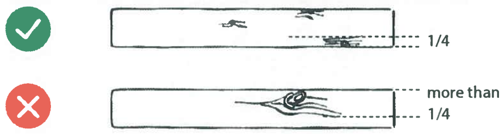
TREATMENT

All timber (and wooden) elements have to be treated against termites and insects in general. Timber should be coated with a preservative treatment before mounting. The timber must be well dried before applying the preservative treatment.

Avoid sloping grain; the grain is different from figure wood and can be difficult to see with the naked eye unless there are splits which will naturally follow the grain.

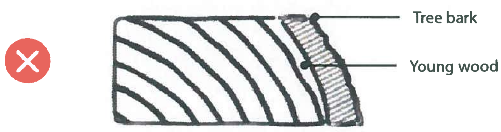


Avoid timber with a lot of knots or knots that are larger than 1/3 the depth of the element, especially knots that cut through the tension fibres of beams. Where making connections ensure there are no knots nearby.



Avoid boxed heart (timber cut from middle of a tree).

Avoid sapwood as this is readily attacked by insects; it is generally paler than the heartwood.



Avoid timber that exhibits signs of insect attack.

Structural Steel

Al structural steel to be mild steel, 275N/mm^2

Appropriate corrosion protection to be applied to all steel. Corrosion protection to be checked and repaired after any connections are made, and also after installation.

WELDING

All welding surface to be clean and free of dust before welding

Welds to be continuous 4mm fillet weld

All welds to be inspected. Check weld size and length. Check for evidence of element damage or derformation.

Corrosion protection to be applied after welding is finished

BOLTS

For bolted connections, check the following:

1. Bolt strength (should be indicated on bolt head)
2. Diameter
3. Bolts spacing's
4. Edge and end distances
5. Washers are in place
6. A minimum of two threads protrude through the nut
7. Corrosion protection to be repaired if damaged

CHAPTER 7

Quality Control on Site

CHAPTER 8

Operation and Maintenance

Regular housekeeping/ maintenance

In order to keep the schools well maintained, it is strongly suggested to do the following tasks on a regular basis:

- check and keep the drains clear;
- check for birds and/or insect nests and remove them;
- keep the rooms clean;
- keep the toilets dry and clean;
- check and replace the light bulbs that do not work;
- check for water dripping and fix it.

The maintenance manager should supervise the execution of the previous tasks, in order to verify that they are correctly performed.

Scheduled ordinary maintenance

The following tasks must be performed monthly by the school staff:

- check for damages in the electrical system (e.g. wiring, sockets, light buttons)
- check for damages in the hydraulic system;
- check the septic tank;
- check if there is guano on the timber beams;
- check if there is rust on the steel elements (e.g. metal roof, joints);
- check the insect protection in particular the protection against termites' attack;
- check the adherence between walls and plaster and plaster preservation;
- check the anchorages of the furniture to the walls (e.g. bookshelves);
- check for deterioration of the furniture;
- check for damages affecting doors and/or windows;
- check for any superficial deteriorations of the ring beam;
- check for any damages affecting the waterproofing elements inside the toilets.

If any issues are identified, an appropriate construction company should be promptly appointed to resolve these issues. The maintenance manager should supervise the checking phase, the selection of a proper construction company and the restoration works.

Extraordinary structure maintenance

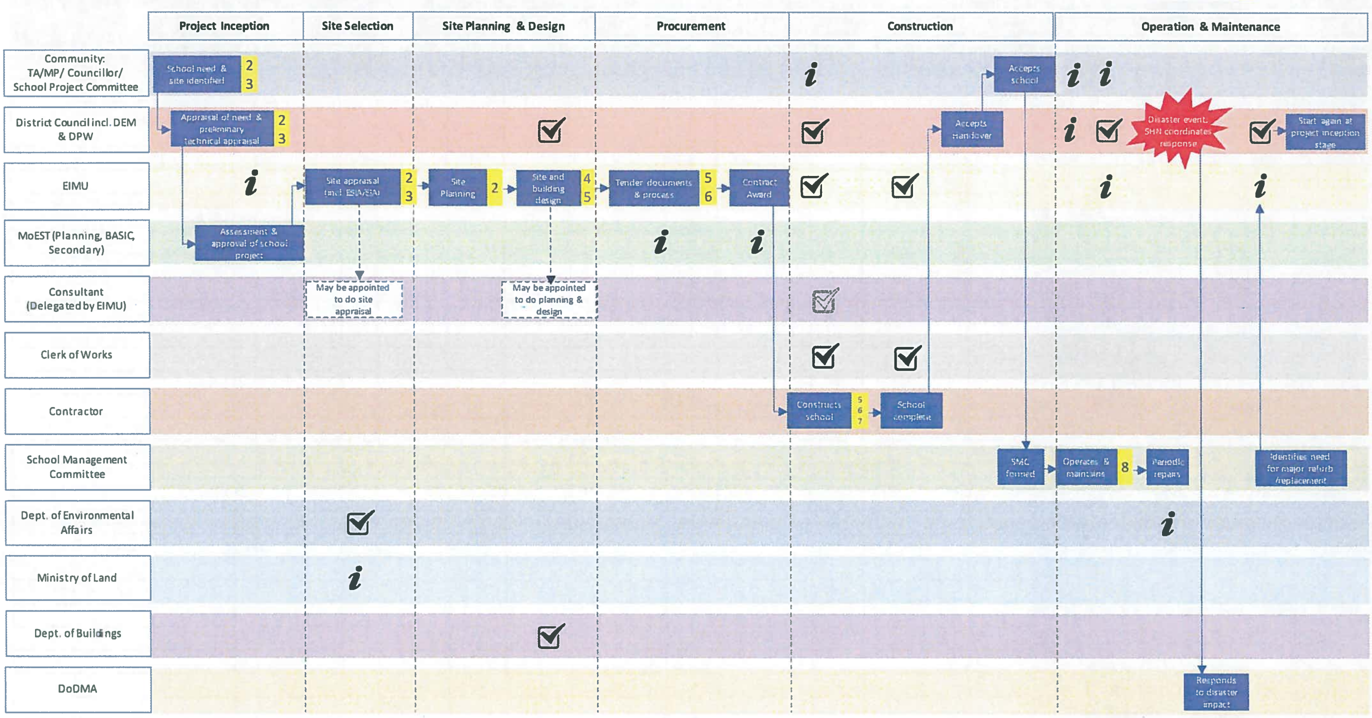
Extraordinary maintenance cannot be planned, so it is not possible to provide an exhaustive work plan. However, in the following paragraph there is a description of the main exceptional issues that can occur during the life of the building.

- the steel roof could rust, so in order to prevent water infiltration inside the rooms it is recommended to replace the corrugated metal sheet which has deteriorated; it is also recommended to replace any rusted roof joints;
- timber elements could adsorb humidity, that causes warping, cracking and twisting; in this case the deteriorated timber element must be replaced;
- a masonry wall not well constructed (eg poor pointing) could be eroded by water and / or wind; in this case both bricks/blocks and joints must be promptly refurbished through pointing with cement mortar;
- the drains could be eroded by floods; in this case the drains surfaces must be restored to their original status;
- the reinforcement bars of the ring beams could rust, because of an inappropriate concrete cover; in this case, the rust must be removed from the reinforcement bars and concrete cover promptly restored with structural cement mortar.

The previous maintenance works must be performed by a construction company specialised in structural works, chosen at the Local Council level. The Local Council also has the role of appointing a technician that supervises the works.

After natural disasters (e.g. earthquakes, floods) it is compulsory that a suitably qualified technical person appointed by District Council checks every structural element of the buildings, to ensure the structural safety.

School Infrastructure Project Implementation Workflow – National Level Projects (Assumes New School)



Responsibility Matrix: School Infrastructure Project Implementation - National Level Projects (Assumes New School)	SSCG Chapter Reference	MoEST (Planning, Basic, Secondary Education Depts.)	EIMU	DoDMA	DPW	DC incl DEM	Community (incl. TA/ Councillor/ MP/ School Project Committee)	School Management Committee	Department of Buildings	Department of Environmental Affairs	Ministry of Land	Site Supervisor (CoW/EIMU/Consultant/DPW)	Contractor	Notes: L: Lead & Co-ordinate S: Support
Site Infrastructure Detailed Design	4		L											
Building Design and Specifications	5		L											
BOQ & Engineer's Estimate		S	L											
Design Review & Approval	4 5		S						L					
Planning Application Submitted			L											This step may not be applicable in every location
Planning Approval			S			L								As above
Procurement														
Updated Project Schedule			L											
Tender Documents Completed			L											
Tender Process Launched			L											
Review of Tenders		S	L											Includes all government internal procurement processes
Contractor Selected		S	L											
Site supervisor appointed (Clerk of Works/ Consultant/ EIMU)			L											
Construction														
Contractor Mobilisation & Site Preparation	4		S		S								L	
Site setting Out	4												L	
Materials Procurement	6												L	
School Construction	5 6 7		S		S								L	
Construction supervision and Quality Control			S		S		S					L		
Materials testing	6		S		S		S					S	L	
As-built Drawings													L	Recommend that this be done for all projects
Maintenance Manuals			S										L	
Practical Completion and Handover to MOEST (via EIMU)		S	S						S				L	
Handover to Community (MOEST-DC- Community)		L				L	S							
Operation & Maintenance														
School Management Committee formed							L							