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Global Programme for Safer Schools

Mozambique Mission Report

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1 Introduction

Each year, natural disasters result in school buildings being destroyed or severely damaged leading to loss of life, injury and disruption to education. Global efforts to make schools more resilient have largely focussed on improving awareness and preparedness, so that teachers and children are better prepared and able to take appropriate action. Less attention has been paid to the physical performance of school buildings, which is the focus of a new initiative by the Global Facility for Disaster Risk Reduction (GFDRR) - the Global Program for Safer Schools (GPSS). This is being designed as a technical assistance program targeting countries where there is on-going or proposed investment in schools infrastructure.

This report provides a summary of the key findings from a short fact finding mission from 3-8 March 2014 to advance the GPSS in Mozambique. It has been prepared by Jo da Silva who was engaged to provide technical support to the World Bank/GFDRR team during this period. It addresses the specific objectives of this assignment, namely:

- To understand the results of the existing work in Mozambique conducted by the World Bank
- To identify potential entry points for action.

The observations made in this report are a result of meetings and visits to schools during this mission, as well as a review of documentation obtained during the visit. Further details are provided in Appendix A.

2 Context

Mozambique is vulnerable to major hazards – earthquakes, flooding, drought, and cyclones. It is situated at the southern end of the East African Rift which is the source of many of the most significant African earthquakes. The most recent major (7.0Mw) earthquake occurred in the western province of Manica in Mozambique on 22nd February 2006. The country is traversed with nine major rivers that cross national boundaries and flow into the Indian Ocean, including the Limpopo and Zambezi. Flooding is a regular occurrence as a result of heavy rainfall compounded by upstream environmental degradation and catchment management. Irregular and limited rainfall also results in water scarcity and drought in the southern provinces. The coastline which is 2470km long is exposed to cyclones between November and April each year. Eleven major cyclones have hit the coast of Mozambique between 1984-2010, bringing torrential rainfall and flooding as well as high winds.

It is not only extreme events, but more frequent relatively minor events, that have resulted in significant damage to schools infrastructure. Between December 2011 and March 2012 almost 200 classrooms were damaged due to flooding or wind.[1] Whilst, this may not involve loss of life or injury, the impact is nevertheless significant. Children's education is disrupted or ceases whilst they wait for repairs to be carried out; this can take several years.

The number of schools in Mozambique had grown steadily since the end of the conflict in 1992. Between 2004-2012 the number of schools increased from 8,886 to 11,544 (33%) as a result of an accelerated construction programme. Currently, approximately 6 million children out of a population of 24 million go to school. However, 46% of primary school children are learning in rudimentary classrooms built from local materials (see Figure 1, Appendix C) or having lessons outdoors. It is projected that some 30-40,000 classrooms are needed by 2025 to meet the current shortfall and accommodate a growing population, including replacing sub-standard structures. Few of the schools constructed over the past decade have properly taken account of natural hazards, and will require retrofitting or replacement. The emphasis on quantity rather than quality and a 'cost ceiling' of \$10,000 (approximately \$180/m^2) contributed to sub-standard construction. In Gaza, costs are currently \$17,000-27,000 per classroom (\$300-500/m^2) but are higher in other areas of the country which are relatively less developed and inaccessible.

[1] Orientações e Princípios para Escolas Seguras em Moçambique

3 Existing work being undertaken by the World Bank in Mozambique

3.1 Education Sector Support Project (ESSP)

The World Bank is providing education sector support to the Ministry of Education (MINED) in conjunction with other FASE[2] partners to support the current Strategic Plan for Education. The overall development objective is to improve access to, and quality and equity of education[3]. Component 1: Improving Access to Education relates specifically to rehabilitation and construction of classrooms, both primary and secondary. Implementation is through DIPLAC CEE.[4] Technical support to enhance their capacity is currently being provided by a German engineering firm[5] funded by KfW who chair FASE's Construction Group.

Quantity and Quality

The safety of schools has not been an objective of FASE to date[6]. Their major concern being the number of classrooms constructed each year which is currently well below the annual target (approximately 1000 new classrooms per year), also escalating costs and construction quality. Greater autonomy of the construction departments is cited in the mid-term evaluation as necessary in order to speed up procurement and contract administration. However, the key issue seems to be limited capacity and skills within MINED at provincial level to take on these responsibilities. Procurement and construction management are normally skills that exist within the Public Works department who may be better placed to take on responsibility for implementation rather than seeking to build DIPAC CEE's capacity at both a national and provincial level.

A further challenge has been 'paralyzed construction' which refers to projects that have been started but not completed, in some cases dating back to 2010. An audit of these works is due to be completed by August 2014 but the prime cause seems to have been poor financial management (under-bidding and over payment).

Damage to poorly constructed classrooms as a result of strong winds or flooding has meant larger number of school buildings need to be repaired. There appears to be no process in place to prioritise repairs and allocated funds.

Typologies

There are three school construction typologies that exist in Mozambique.

1. *Old Methodology*

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[2] FASE refers to the Education Sector Support Fund (ESSF or FASE in Portuguese) to which 9 other donors contribute: Ireland, CIDA, Finland, Germany, DIFD, Portugal, UNICEF, Italy and Flanders Cooperation.
[3] Education Sector Support Project (ESSP) Mid-term Review Mission, September 30-October 1, 2013
[4] DIPLAC CEE is the construction unit within MINED.
[5] Grontmij GmbH
[6] 'Safety' is used by some partners (UNICEF and DFID) in the context of security of individual children; requiring boundary fencing for example.

Classrooms that are being built using FASE funds (approximately 1000/year) adopt a standard design approved by MINED which is referred to as the 'old methodology'. (See Figure 2, Appendix C).This form of construction is also supported by various INGOs including ActionAid, Save the Children, World Vision co-ordinated through MINED at provincial level, although the numbers involved are relatively small; 80-100 per year. The classrooms are rectangular, single storey buildings typically 56m^2 constructed from concrete blocks with galvanised iron roof sheets on timber trusses. FASE are concerned about construction quality (see Figure 3, Appendix C), as well as the slow speed of construction.

2. New Methodology

A few years ago, an alternative form of construction was introduced comprising a pre-fabricated steel frame, with the infill walls constructed subsequently using local labor. Referred to as the 'new methodology' this has potential advantages in terms of speed of construction and predictability of structural performance. In practice, lead-in times and delivery to remote areas has resulted in delays and additional costs. Other difficulties are thought to include: availability of skilled labor to erect the frames, tolerance of holding down bolts and completion of non-structural elements (walls, windows, doors etc). The FASE mid-term evaluation highlights the need to evaluate the pilot programme by August 2014 in order to decide whether it should be pursued, and if so how it should be modified.

3. Conventional

FASE does not support the construction of classrooms using 'conventional' local materials (stakes, mud, grass, reeds, stabilised soil blocks) which accounts for around a further 1000 classrooms per year (See Figure 4, Appendix C). These are built spontaneously by community groups using their own funds to purchase materials and engage local craftsmen or builders; therefore the typology and resultant quality depends on local practices. This form of construction is sometimes supported by NGOs who provide financial and/or technical assistance. These 'conventional' classrooms make a significant contribution to the shortfall in infrastructure and are recognized by, though not funded by MINED[7]. Teachers are provided by MINED for completed classrooms. Such classrooms were described by MINED as 'transitional'; the aspiration is that they will be replaced with a more robust structure eventually.

3.2 UN-Habitat

The World Bank/GFDRR initiated a Safer Schools Programme following severe flooding which affected more than 1,000 classrooms in the provinces of Maputo, Gaza and Zambezia in 2011. Technical assistance has been provided by the United Nations Programme for Human Settlements (UN - Habitat) and the Faculty of Architecture and Physical Planning of the University Eduardo Mondlane (UEM - FAPF).

Awareness

A key success of the programme has been generating political consensus on the need for safer schools amongst MINED the Ministry of Public Works (MoPH)

[7] The District Education Service provide teachers once projects are completed

and the National Institute of Disaster Management (INGC) which sits within the Ministry of State Administration (MAE). There is now a strong awareness of hazards, the number of schools located in hazard-prone areas, and recognition of the financial implications associated with repairing, retrofitting or replacing schools that are damaged or have collapsed.

There is also agreement that the cost ceiling for classrooms that was previously imposed has contributed to poor quality. The study suggests that an average classroom costs $25,000 and the repair of a partially destroyed classroom costs $4,000; several hundred classrooms are partially destroyed each year.

Analysis

UN-Habitat has completed a comprehensive analysis, including a survey of 636 classrooms across 7 provinces, to explore the legal, institutional and technical issues affecting safer schools construction. This has been a participatory process which is well documented[8]. The report identifies the systemic weaknesses in current approaches to schools construction that leave school buildings susceptible to four natural hazards – flood, cyclones (or strong winds), earthquakes and drought. The key findings can be categorized as:

- Direct factors: absence of scientific data and hazard maps, lack of site assessment/physical planning, inappropriate designs, poor quality construction (materials and workmanship);
- Indirect factors: inadequacy of the regulatory environment, limitations in the capacity of government (procurement, contract administration), and weak contractors (construction management and site supervision).

As a first step towards addressing the direct issues UN-Habitat has been developing Hazard Zoning Maps and Technical Guidelines (also referred to as a Catalogue of Norms) which are almost complete.

Hazard Zoning

A copy of the report 'Document of Hazard Mapping; Zoning; Schools Exposure Risk Mapping of Mozambique' was provided by UN-Habitat. Writing such a report is a significant undertaking, particularly where data is limited. A substantial effort has been made to assemble information on four key hazards from a range of international and national sources, and a number of local institutions have been involved in the process[9]. However, the validity of this report is questionable as it does not establish a clear scientific basis for using particular data, nor include a robust methodology for creating the maps using data from various sources. There are also a number of technical inaccuracies; repetitions and misrepresentations (see Appendix B).

The report is not clear about who will use these maps, or why. They do not provide the detailed information that an engineer would need in order to design a safer school, such as design wind speed or peak ground acceleration. Meanwhile, comments made in meetings with both MINED and MoPW suggest they intend to use these maps to justify resettlement programmes. UN-Habitat's original intent

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[8] Orientações e Princípios para Escolas Seguras em Moçambique

[9] The report refers to DNG; DNA; INAM; ARA-SUL; FEWS NET; INGC and Faculties of Geology, Sciences and Architecture from UEM.

seems to have been to make the case for Safer Schools by highlighting that much of the country is prone to frequent natural hazards, therefore schools infrastructure faces high levels of exposure. However, this could have been achieved by referencing the World Health Organisation e-Atlas, developed in 2011[10]. There is an issue of whether the data that is used in the e-Atlas is up to date and appropriate but it is widely referred to.

Catalogue of Norms

UN-Habitat gave a detailed presentation of the material to be included in the final Catalogue. This proposes adaptive measures and improved details based on the 'old methodology' that result in a Safer School (or safer schools as it is not clear to what extent the details are engineered). Examples include, separating the external canopies from the main roof (Figure 4, Appendix C), and ensuring roof trusses are tied down. The material is very well presented employing a combination of diagrams, drawings, photographs to describe the key elements and details. This is supported by straightforward explanations (text and diagrams) which illustrate how a school building resists hazards such as cyclones and earthquakes.

At present the intention is to provide guidance that is specific to each of the four hazards in separate chapters. However, this assumes that whoever is referring to the catalogue knows which hazards are present, and is able to decide which details to adopt if more than one hazard is present. UN-Habitat have proposed that this Catalogue is ultimately adopted by MINED as a standard for Safer Schools Construction, and enforced through legislation but the process for achieving this is not clear.

Community Assistance

UN-Habitat has also been supporting community schools construction providing technical assistance to improve local construction practices employing local materials and adaptive architecture. An example of this is a 2 classroom block built from stakes and rubble covered in cement plaster with a double-hipped roof on timber trusses (Figure 6 & 7, Appendix C). This was constructed in only a few weeks by the community plus two skilled laborers. It represents a very significant improvement in quality and ability to withstand strong winds as compared to the existing classroom (Figure 8, Appendix C). Further optimization may be needed to reduce the complexity of the roof, the requirement for skilled labor, and the cost if it is to be widely replicated.

Elsewhere, UN-Habitat have improved the safety of community schools in flood prone areas by constructing them on raised mounds. In Choke they have constructed a classroom raised a full storey above ground level (Figure 9, Appendix C), which is intended to act as a community refuge when there is severe flooding. It is noted that this design would be inappropriate in areas of high seismicity due to the soft storey.

[10] http://www.who-eatlas.org/africa/foreword.html

4 Potential Entry Points for Action

4.1 Understanding hazards

The absence of scientific data and robust hazard maps remains a significant limitation to achieving safer schools, and Disaster Risk Management (DRM) generally. Although, there are high levels of awareness of flood, cyclones and drought due to recent events, seismic risk is seldom considered[11]. Information is needed on the likelihood of a particular type and magnitude of event occurring in order to quantify risk. Likewise, information on wind speeds, ground accelerations and return periods for flood events is needed to establish a design basis for schools (and other infrastructure) that is ultimately incorporated in Building Codes and standards. This is a significant undertaking, resulting in outputs that will support safe construction generally, not just for schools.

Recommendation 1: Carry out a technical review of UN-Habitat's hazard mapping. This should be done by an expert (or team of experts) in geo-hazards and hydro-meteorological hazards. In order to inform next steps, the review should include an assessment of the technical capacity of national institutions to develop hazard maps, the availability of scientific data, and efforts by others to map hazards in Southern and Eastern Africa.[12] Based on this review, determine the road map for developing robust hazard mapping to be incorporated in the planning/building regulations, updated periodically, and made widely available.

4.2 Site Location and Physical Planning

There seems to be little, if any, consideration of natural hazards in determining where schools are located, and no attempt to mitigate exposure through the physical planning of the site; orientation of buildings, site drainage, avoiding steep terrain. It is not clear where responsibility for this lies, or whether budgets are even allocated to site preparation. UN-Habitat have already started to develop simple guidelines for carrying out high level site assessments and avoiding siting building close to steep slopes or on unstable ground. There is an opportunity to develop site planning guidelines specifically for schools, to ensure that buildings are appropriately orientated, drainage or retaining walls provided where necessary. This represents an important shift away from thinking about schools simply in terms of classrooms, and recognising that vulnerability is not only dependent on the classroom construction.

Recommendation 2: Work with a local industry partner (firm or institution) to develop site selection and planning guidelines specifically for schools construction that mitigates risk.

[11] Seismic design is not taught to engineers and architects, and is not included in the National Building Codes

[12] For instance, Arup are developing a new probabilistic seismic hazard assessment for the E Africa region that could be extended to create a seismic hazard map for Mozambique.

4.3 Quality of design

The vulnerability of classrooms to natural hazards stems from inappropriate design. This is further compounded by poor quality construction (workmanship and materials), but even if well-built there are inherent weaknesses with the designs provided to the contractor.

The standard primary school classroom design ('old methodology') employed by MINED was apparently developed by a South African firm, in accordance with the South African Building Code. A fully detailed set of drawings and specifications exist, but have not been adopted as they do not reflect local construction practices and are considered costly. Instead, it is left to the provincial engineer, or a local architectural firm, to adapt the design and reconcile costs with budgets. Key details which are critical to the structural integrity are often omitted. It is not clear where design responsibility rests legally. There is no process for review or verification, and no requirement that the design complies with the National Building Code or other standard. Furthermore, the National Building Code (1961) is out of date and does not provide a robust basis for justifying the design of schools; it does not consider seismic risk and the wind map is derived from a map of Portugal.

The quality and completeness of design documentation is a further issue. The drawings on which a contractor's bid is based and from which they build do not classify as full construction information; this implies details of all connections, general arrangement drawings (plans), sections and elevations as well as specifications. UN-Habitat have also identified the need to ensure that the information is presented in a clear format that contractors can understand easily, and reflects local building practices. Without complete information, the contractor is left to interpret the design as they see fit but takes on no design responsibility or liability in doing so.

There are a number of potential ways to improve design quality:

1. *Technical norms*

The Catalogue that UN-Habitat are developing provides accessible guidance on appropriate forms of construction and best practice. These will be a valuable tool for promoting safe construction, and a key reference for provincial engineers and contractors. It has been suggested that these might be adopted as 'technical norms' for schools and made mandatory through incorporation in the building regulations. However, the mechanism to achieve and enforce this is not clear.

2. *Project Requirements*

Given the high demand for classrooms, there is potential to engage the private sector. The starting point would be to consult with FASE and MINED to create a comprehensive technical design brief for primary and secondary schools. This would define the design basis referring either to the Eurocode, South African code or International Building Code (IBC), and would include guidance on the loads (wind, seismic etc.) that should be assumed in different provinces based on published data, or site specific investigation. It should include objectives and key performance indicators that could be used to evaluate construction. This would allow local architects and engineers to develop a range of designs, applicable to different areas of the country. There appears to be capacity within the private sector to undertake designs, potentially also to undertake (or support) the contract administration and site supervision to ensure that the design intent is not compromised.

3. Model School

The process described above might seek to create a Model Safer School Designs with adaptations that are applicable to the combination of hazards that exist in specific areas of the country. Various designs (drawings, specifications, bills of quantities) could be piloted, evaluated and optimized, potentially leading to a number of Model School (or Model Classroom) designs that could be replicated at scale. This process should include value engineering and design optimization to ensure the designs are cost-effective and meet key performance requirements (safety, size, ventilation, temperature, light etc). Arup have previous experience of a similar approach in Ghana which required large numbers of kindergarten classrooms.

Recommendation 3: Provide technical assistance through an international and/or local industry partner (firm or institution) to support MINED/DIPLAC-CEE to develop a comprehensive technical design brief for primary school classrooms informed by international best practice[13]. Engage local/international consultants to develop Model School Designs using UN-Habitat guidelines as a key reference. Tender documentation (drawings, specifications, bills of quantities) should be independently evaluated against the technical brief, and the designs also assessed in terms of buildability and post-occupancy assessments.

4.4 Quality of Construction

The challenge resulting from an inadequate or poorly communicated design is further compounded by poor quality materials and workmanship. Current quality standards are a reflection on the calibre of contractors, availability of skilled labour, and cost of materials locally, but also MINED’s capacity to enforce the contractual requirements.

1. Contractor Selection

In Mozambique contractors require registration but the technical staff they engage in order to achieve registration are not necessarily engaged longer term. Many smaller firms have limited experience and capacity. Contractors are licensed to operate throughout Mozambique, and Class III contracts (contracts up to $800,000) are eligible for schools projects. These are tendered individually or in small lots. Two stage tender processes, preferred lists of contractors and selection on the basis of quality and cost are potential mechanisms to ensure competent contractors are engaged but are not common in Mozambique.

2. Skilled Labor

Shortage of construction skills is an issue throughout Mozambique. There are efforts to address this through the National Institute for Employment and

[13] For GPSS this should focus on safety but this process provides an opportunity to determine other key performance criteria including, comfort, lighting, ventilation, security etc.

Vocational Training (INEFP) and PIREP[14] which has received World Bank funding.

3. Materials

The availability and cost of materials varies significantly throughout Mozambique but this is not necessarily accounted for in the specifications or the budgets that are made available. Processes to verify the quality of materials on delivery are also not common.

4. Construction Management

Weak construction management is a key issue, notably the lack of quality assurance processes such as material certificates, inspections at critical stages, and authorization of variations. There should be an experience site manager on each site throughout the construction period to oversee the process, quality and ensure that the final product reflects the design and specifications.

5. Contract Administration/Site Supervision

MINED's capacity and capability at the provincial level to manage procurement, administer the contract and monitor construction is limited. The engineer we spoke to in Gaza only had a team comprising himself and two technicians with responsibility for delivering 70 classrooms last year. Given such limited resources, site supervision and inspections to verify the basis for payments is a challenge; especially when construction sites are spread out or in remote locations. It has been proposed that responsibility for procurement and implementation might be passed over to the local Public Works department but no assessment has been made of their capacity. An alternative approach might be to engage private sector consultants to act as contract administrator and carry out site inspections.

Recommendation 4: Provide technical assistance to optimize the delivery of schools funded by FASE in terms of quality (including safety) and quantity focussing on two or more districts. An approach that considers schools construction throughout the province as a multi-year programme and engages private sector partners to support and build the capacity of the Ministry of Education (MINED/DIPLAC-CEE) and the Ministry of Public Works and Housing (MOPH/DNE) at district and local level is programme is recommended.

4.5 Community Build

Providing technical assistance to community build programmes offers significant opportunity to improve the performance of 'transitional classrooms' which play a significant role in addressing the overall demand for school infrastructure. They are significantly cheaper than the government buildings, and the building process creates ownership of the building which encourages maintenance, particularly if local materials and building practices are adopted. Communities also often have a good understanding of local hazards and are well placed to select suitable sites.

Designs for school buildings to be built by communities should be considered and communicated in a different way to that of a contractor build process as they will

[14] http://www.pirep.gov.mz/

need to be understood by a non-technical, unskilled and /or illiterate workforce. Technical assistance, such as, clear and simple step by step construction guidance, training and oversight during construction can significantly enhance the quality of the school building. UN-Habitat and various NGOs are already supporting this type of construction through pilot programmes. The challenge and opportunity is to deliver such programmes at scale.

Recommendation5: Collate and analyse the strengths/weaknesses of existing approaches to construction of community schools; identify the key features/practices that result in safe construction; and provide technical assistance (training, tools, skilled labor) that enables the MOPH/SDPIs at district level and the focal points of INGC (through the Local Committees for Disaster Management) to promote safer construction practices on community build programmes[15].

4.6 Repairs, Retrofitting

Mechanisms are needed to retrofit schools constructed using FASE funds that are inadequate; likewise, to facilitate rapid repairs to schools that have been damaged as a result of natural hazards. In Gaza, 140 classrooms are currently considered damaged as a result of strong winds over recent years. UN-Habitat have developed an assessment methodology and their survey has identified the key weaknesses which provide a good basis for designing a repair and retrofitting programme.

Recommendation 6: Establish an emergency fund and processes to undertake rapid repairs of schools that have been damaged as a result of natural hazards.

Recommendation 7: Undertake of an assessment of all classrooms constructed using FASE funds based on the methodology developed by UN-Habitat to scope a potential retro-fitting or replacement programme in each district.

[15] This has the potential to also influence other community based construction such as individual housing.

5 Conclusions

There is a significant deficit of school infrastructure in Mozambique, as well as high levels of exposure to natural hazards. Improving the quality of construction in order to reduce the vulnerability of school buildings to natural hazards, must be balanced with the need to build quickly in order to address the chronic shortage of schools infrastructure. Technical assistance provided through the Global Programme for Safer Schools (GPSS) should therefore be targeted on improving community-build schools, as well as those constructed through the FASE programme, since at present both contribute almost equally to addressing the demand. For both, there is opportunity to build on UN-Habitat’s work and develop replicable technical solutions that can be scaled-up, whilst taking account of the different hazards, capacities, materials and costs in different provinces.

There are weaknesses at every step of the design/construction process: planning, design, procurement, contract administration, construction management, site supervision. These need to be systematically addressed, starting with developing robust, appropriate and affordable design(s) that account for variations in hazards, capacities, demands and logistical constraints in different districts.

Based on this visit, we suggest that the World Bank/GFDRR invest in a several year programme to improve schools safety in two or three districts initially that responds to the recommendations above. It should include preparation of tools, guidelines, processes and training that can be used to transfer the learning to other districts. Whilst, the demand for schools infrastructure over the next decade provides a unique opportunity for preventative action, the need for corrective action to address the shortcomings of schools that have been built in recent years in the selected districts should not be over looked.

Wider investment to improve the policy and regulatory environment to achieve safe construction generally - not just schools is needed. Robust hazard mapping is essential. Consideration should also be given to developing a Building Code (or Standards) for Schools Construction based on an international code such as the Eurocode or IBC.

Appendix A: Mission Details

Field visit

Two days were spent in the field visiting schools in Gaza Province in the vicinity of Chokwe and Xai-Xai which also provided an opportunity to meet with members of the Council of Chokwe, and staff from the Ministry of Education (local) responsible for construction and operations.

References

- Education Sector Support Project (ESSP) Mid-term Review Mission September 30-October 11 2013
- Orientações e Princípios para Escolas Seguras em Moçambique (UN-Habitat: November 2013) – draft
- Annex IV: Document of Hazard Mapping; Zoning; Schools Exposure Risk Mapping of Mozambique (UN-Habitat) - draft
- Assessment and Delivery of Safer Schools (Arup: December 2013)

Appendix B: Hazard Observations

The following observations based on a preliminary review of UN-Habitat's report 'Document of Hazard Mapping; Zoning; Schools Exposure Risk Mapping of Mozambique'.

Earthquake Hazards

- The definitions of intensity and magnitude are incomplete and need significant amendment.
- The report should include a listing of the key earthquake events that have affected the country and a clear explanation that the data set is very small and incomplete.
- Figures 3, 6, 10 and 14 are examples of old maps that has been geo-referenced and made to appear newer. The reference to the original maps is not provided, so the reader has a misconception of the veracity of each map. Furthermore, no review of the appropriateness of these maps has been undertaken.
- Figures 5, 11, 12 and 13 all show the same data from the global seismic hazard programme (GSHAP, 1999).
- Figure 14 which shows the geo-referenced seismic hazard map for Mozambique is factually incorrect, by a factor of 10. They have stated the hazard varies from 0.2 to 1.6g; it should state 0.2 to 1.6m/s2. The map also fails to state that it represents ground motions on rock.
- There is no discussion of the veracity of the GSHAP map for the East African region. Several authors have suggested that it underestimates the seismic hazard. Unfortunately, there is no better study available at this time, though Arup are aware of seismic hazard studies being carried out for northern Mozambique for the oil & gas industry. Arup is also undertaking an independent study for the whole East African region. These studies could be used to help define a new seismic hazard map for Mozambique, but this would require additional investment.
- There is no discussion of secondary earthquake hazards, such as fault rupture, liquefaction and slope instability, which are equally important to the performance of the built environment.

Cyclones

- As with the earthquake maps, the report geo-references existing data as if new and does not provide either critical review or the supporting data and references for the maps.
  Many building codes (e.g. ASCE 7) assume the wind speed is defined by a 3 second gust at a height of 10m and a return period of 50 years. In the UK a 1 hour average speed is used. There should be a clear statement that confirms the definition of the wind speeds presented in the report.
- The description of the wind speeds in Figure 18 is not stated and potentially contradicts other data presented in the report. The peak wind speed is quoted as 20m/s (i.e. 72kph or 45mph) for a 20 year return period. This seems to be inconsistent with the report itself which states that 14 cyclones have affected the country in the last 20 years. It is hard to believe only one of those cyclones exceeded a windspeed to 20m/s. Figure 19 suggests this may be a daily average wind speed, which would be inappropriate for design purposes.

Floods and Droughts

- As before the report geo-references existing data as if new and does not provide either critical review or the supporting data and references for the maps.

Risk to Schools

For each hazard the position of the schools has been overlaid on the various hazard maps and it is implied that this represents the risk. In fact, it only provides an indication of the exposure of a school, which may be increased or reduced as a result of more local factors such as topology, terrain and ground conditions. The risk is the combination of hazard, exposure and vulnerability; the latter being a function of how the school has been designed and constructed.

Appendix C: Figures of images from Mozambique

Figure 1

A ‘conventional’ **classrooms built by** local unskilled labour and **local materials**.

Figure 2

'Old Methodology' classrooms built using concrete blocks with a galvanised iron roof sheets on timber trusses

Figure 3

Poorly detailed timber trusses and connections to roof sheets

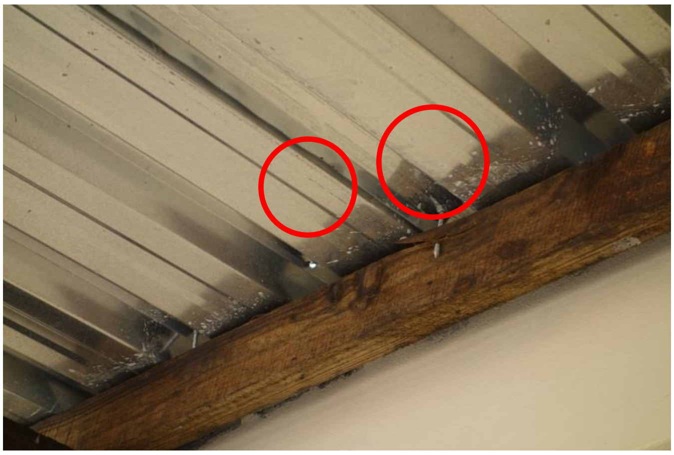

Figure 4

Community built construction built from local mud and timber.

Figure 5

External canopies separated from the main roof structure to avoid roofs being ripped off in high winds

Figure 6

Internal view of UN-Habitat Community Build classroom built from stakes and rubble to be covered in cement plaster

Figure 7

Local labour plastering he external face of the classroom block

Figure 8

Poor quality existing classrooms built by community labour with limited skills and resoruces.

Figure 9

Classroom in Choke raised a full storey above ground level in order that it can act as a community refuge during periods of severe flooding.