PROJECT: ZIMBABWE (MUTARE) MEDICAL WAREHOUSE

DESIGN CRITERIA REPORT
FOR CIVIL AND ARCHETICTURE WORK

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1- INTRODUCTION

The Government of Zimbabwe through the national pharmaceuticals company NatPharm and the Ministry of Health and Child Welfare are aiming to construct a medical warehousing at Mutare. Funding is sourced from the Global Fund through UNDP Zimbabwe as the Principal Recipient (PR). Other actors are the Ministry of Public Works, the Local Authorities and Councils.

The warehouse will be constructed at an empty land as per the coordinates and outlined aerial view of the site boundaries (outlined in red) below:

Location	Latitude	Longitude
Mutare, Zimbabwe	18° 58’ 00.48” S	32° 39’ 34.05” E

Cosmos-E Engineers & Consultants was awarded the engineering design works of the Civil, Architecture and MEP work for all buildings in the project. Also **Cosmos-E Engineers & Consultants** was requested to provide design criteria. The main purpose of the current report is presenting our recommendations for the Arch., Civil and steel structure design criteria including materials, loads and load combination.

2- BASIS OF DESIGN

2-1- GOVERNING CODES AND STANDARD

Unless specifically stated otherwise in the documents, the structural design shall be based on the codes and standard listed below.

- **BS 8110, BRITISH STANDARD**
  STRUCTURAL USE OF CONCRERTE.
- **BS 5268, BRITISH STANDARD**
  STRUCTURAL USE OF TIMBER.
- **BS 5950, BRITISH STANDARD**
  STRUCTURAL USE OF STEELWORK IN BUILDING.
- **BS 6399, BRITISH STANDARD**
  LOADING FOR BUILDINGS.
- **UBC-97**
  Uniform building code that used for calculation both wind and seismic loads.
- **ACI-360R-92 (Reapproved 1997)**
  DESIGN OF SLAB ON GRADE – REPORTED BY ACI COMMITTEE 360.

2-2- MATERIALS

2-2-1- CONCRETE

- Reinforced concrete shall have a minimum cube strength after 28 days as mentioned in the hereafter table with normal Portland cement conforming to the geotechnical investigation report.

Grade	Characteristic Strength after 28 days (Mpa)	Uses
A	C40	Grout
B	C30	All other Reinforcement Concrete Elements
C	C15	Plain concrete

2-2-2- REINFORCEMENT & STRUCTURAL STEEL

- Reinforcing bars shall be deformed bars with minimum yield strength 460 Mpa conforming to BS4449-carbon steel bars for reinforcement of concrete for bars >8mm.
- Steel structure sections shall with minimum yield strength 355 Mpa conforming to BS EN 10025 and BS 5950
- Reinforcing bars shall be deformed bars with minimum yield strength 250 Mpa conforming to BS4449-carbon steel bars for reinforcement of concrete for bars ≤8mm.

2-2-3- CLEAR REINFORCEMENT COVER

The concrete cover shall be as follow:

Clear cover for foundation: 50 mm	Design reinforcement cover =65mm
Clear cover for columns/pedestals exposed to earth or weather :40 mm	Design reinforcement cover =55mm
Clear cover for walls: 35 mm	Design reinforcement cover =45mm
Clear cover for beams: 40 mm	Design reinforcement cover =45mm
Clear cover for slabs: 35 mm	Design reinforcement cover =40mm

2-3- LOADS

Structures will be designed to resist full dead and live loads, with appropriate combinations with earthquake or wind forces effect etc.

2-3-1- DEAD LOAD

Dead loads are defined as the weight of all permanent structural and non-structural components of the building, including, but not limited to, floor finishes, raised flooring system, walls, ceiling, roofing, stairs, fixed mechanical, electrical equipment and any overburden.

1- Own Weight of Reinforcement Concrete 2.50 t/m^3

2- Own Weight of Plain Concrete 2.20 t/m^3

3- Own Weight of Steel 7.85 t/m^3

4- Own Weight of Block Work should be taken as per the approved material at site and assumed to be taken 1.80 t/m^3 in load calculation as more conservative.

5- Super imposed dead loads

Table 1 Superimposed Dead Loads

Superimposed Dead Loads	Uniform (t/m^2)
False ceiling, AC ducts & utilities for Concrete Floors	0.05
AC ducts & utilities for steel roofs	0.05~0.1
Flooring Cover for Concrete Roofs	0.35
Flooring Cover for Floor	0.20

2-3-2- LIVE LOAD

The live loads are defined to be loads due to the intended use and occupancy of a floor area or as recommended by the manufacture requirements and include all movable equipment. Live loads are listed in table 2.

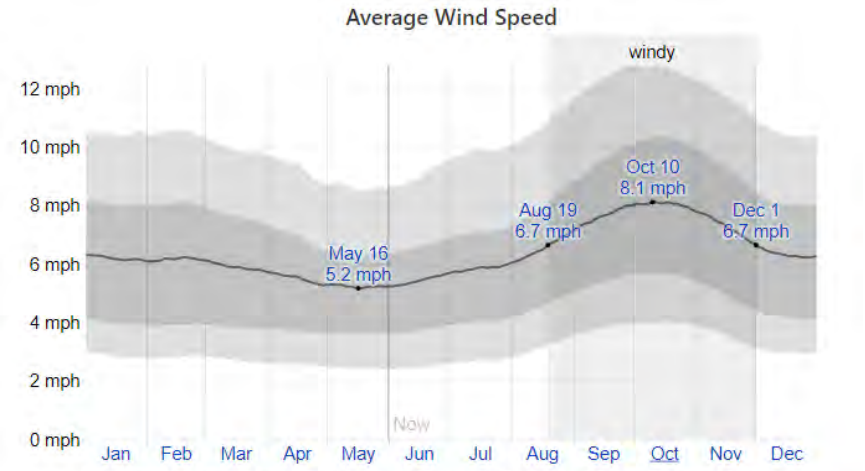
Table 2 Live Loads

Occupancy of use	Uniform (t/m^2)
Inaccessible inclined Roofs	0.10
Mechanical load on floors	0.10
Office for general use	0.25
Kitchens	0.30
Rooms with mainframe computer or similar equipment	0.35
Stairs and Corridors	0.30
Toilets	0.20
Projection rooms	0.50
Bulk storage	0.50 or (0.2*H) where H height of stored shelves. which is bigger.

2-3-3- WIND LOADS

The wind speed is computed in accordance weatherspark.com as mentioned below, the average wind speed is 8.1 mph (3.60 m/s). Therefore, the wind load will be calculated with reference to UBC-97 code with basic wind speed 70.0 mph (31.1) m/s.

Wind loads shall be considered to act in at least two orthogonal directions, not concurrently.



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

In accordance with UBC 97 code for force and load computation in structures and buildings. The wind load acts of the external façade of the Building and therefore affects the design of the perimeter walls and foundation only

$$W = C_e\, C_q\, q_s\, I_w$$

where

q_s Wind stagnation pressure = .0479 x 12.60^2 Table 16-F

C_q Pressure Coefficient = 0.8 inward, 0.5 outward according to Table 16-H.

C_e Combined height exposure (**EXPOSURE D)** and gust factor coefficient according to Table 16-G.

I_w Important factor = 1

2-3-4- SEISMIC LOAD

According to the report on seismic activity in Zimbabwe, the seismicity of Zimbabwe can broadly be divided into three broad zones namely the Zambezi basin, the eastern border areas and the central region. Among these the most seismically active regions are the Zambezi basin then the eastern border areas, then central region is considered aseismic although some earthquakes have been recorded. The following map received from "MINISTRY OF ENVIRONMENT, WATER AND CLIMATE Meteorological Services Department" shows the earthquake distribution in Zimbabwe and surrounding areas. Noticing MUTARE is located in the eastern zone.

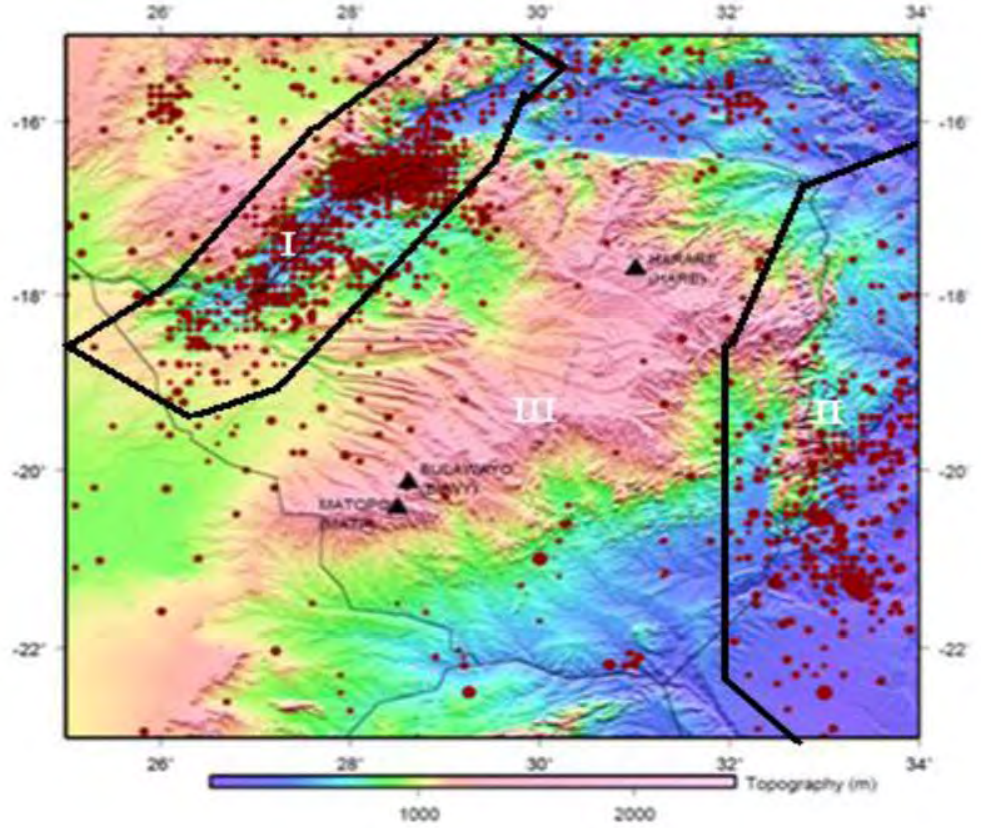
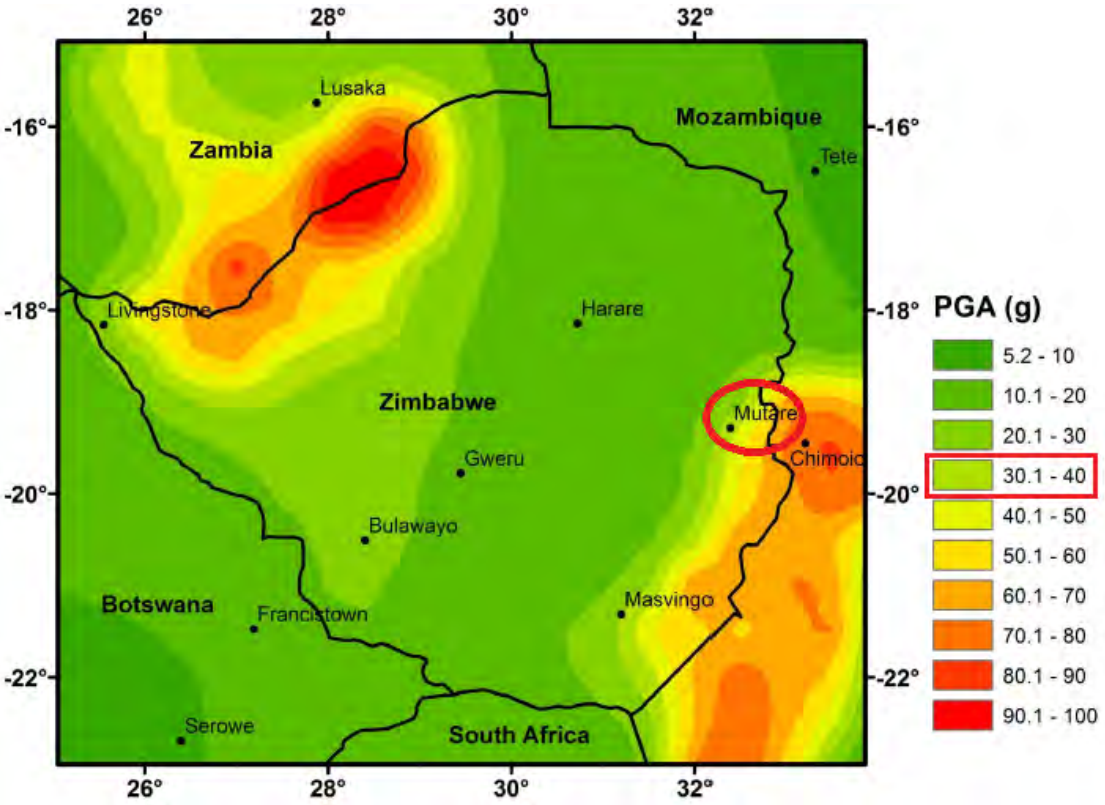


Fig 2: Seismicity of Zimbabwe. The data was collected from 1910 to present *(Shumba and Chibi, 2010).*

The seismic design shall comply with the UBC-97 for seismic loads, while ground acceleration at MUTARE will be considered 0.4g according to the attached assessment of seismic hazard potentials in Zimbabwe by CTBT: science and technology 2017 conference.



"ASSESSMENT OF SEISMIC HAZARD POTENTIALS IN ZIMBABWE BY CTBT: SCIENCE AND TECHNOLOGY 2017 CONFERENCE"

The total seismic ultimate load V (Base shear) can be computed using the following formula:

$$\mathbf{V= (C_v \, . \, I \, / \, R \, .T). \, W}$$

The total design base shear need not exceed the following value:

$$\mathbf{V= (2.5 \, C_a \, . \, I \, / \, R). \, W}$$

and, the total design base shear shall not be less than the following value:

$$\mathbf{V= (0.11 \, C_a . \, I \,). \, W}$$

Where,

Zone	ground acceleration = 0.4g (considered zone 4)
S	Type of soil section as per specified on Geotechnical Report equal to S_c.
C_v	Seismic coefficient, as set forth in table 16-R
I	Importance factor given in table 16-K
R	Numerical coefficient representative of the inherent over strength and global ductility capacity of lateral-force-resisting system, as set forth in table 16-N or 16-P.

T	Elastic fundamental period of vibration, in seconds, of the structure in the direction under consideration = from dynamic analysis.
C_a	Seismic coefficient, as set forth in table 16-Q
W	The total Gravity loads the considered in the seismic load calculation.

LOAD COMBINATIONS

The structural analysis and design shall be considered using the following loads combination for Civil Works as per UBC-97 Code:

For stability, deflection calculation working loads should be considered.

For all other design elements ultimate stress design method should be considered

Working Combination (Serviceability Limit State)

S 1 = D

S 2 = D + L + Lr

S 3 = D + L + S

S 4 = D + W

S 5 = D + E/1.4

S 6= 0.90D $\pm$ E/1.4

S 7= D+0.75 (L+ S+W)

S 8= D+0.75 (L+ Lr +W)

S 9= D+0.75 (L + Lr + E/1.4)

S 10= D+0.75 (L +S + E/1.4)

Ultimate Combination (Ultimate Limit State)

U1 = 1.4 D

U2 = 1.2 D + 1.6 L + 0.5 Lr

U3 =1.2 D + 1.6 L + 0.5 S

U4= 1.2 D +1.60 Lr + F_1 *L

U5 = 1.2 D +1.60 S + F_1 *L

U6 = 1.2 D +1.60 Lr + 0.8W

U7 = 1.2 D +1.60 S + 0.8W

U8 = 1.2 D+1.3W+ F_1 *L+0.5Lr

U9 = 1.2 D+1.3W+ F_1 *L+0.5 S

U10= 1.2D+ 1.0 E+ F_1 *L

U11= 1.2D+ 1.0 E+ F_2 *S

U12= 0.9D ±1.0E

U13= 0.9D ± 1.3W

U14=0.75(1.40D +1.40T +1.70L)

U15=1.40 (D+T)

Where the load categories are described as follow:

D = dead loads, or related internal moments and forces

L = live loads, or related internal moments and forces (to identify the Live Load cases relevant to the Cranes, the letter "C" will be used instead of the letter "L")

Lr = Roof live loads.

W = wind loads, or related internal moments and forces

S = Snow Loads

E= load effects of Seismic forces (Earth quake,) or related internal moments and forces.

F_1= 1.0 For Floors in places of public assembly, for live loads excess of 100 Psf (4.9Kn/m2), and for average live load.

=0.50 For other live loads.

F_2=0.70 For Roof configuration (such as saw tooth) that do not shed snow off the structure.

= 0.20 For other Roof configuration.

T= ±20 ℃ for concrete structure, Cumulative effects of temperature, creep, shrinkage, differential settlement and shrinkage compensating concrete.

T= ±30 ℃ for Steel structure.

2-4- SOIL ALLOWABLE BEARING CAPACITY FOR FOUNDATION

In accordance with the current soil investigation report, the average soil bearing capacity at founding depth is 2.00 kg/cm^2, the minimum recommended founding depth being 2.0m below natural ground level. The following parameter is used for retaining wall:

ϕ =24

$\mathbf{k_a}$=0.422 $\mathbf{k_{a=}}$ Active earth pressure

$\mathbf{k_p}$=2.371 $\mathbf{k_{p=}}$ Passive earth pressure

$\mathbf{k_o}$=0.593 $\mathbf{k_{o=}}$ At rest earth pressure

While in case of inclined earth surface another equation will be used.

2-4-1- Soil bearing capacity of pad foundations

It is assumed that pressure under plinths has a linear distribution in both direction of flexure. Maximum pressure is checked to be less than allowable pressure indicated in geotechnical report. Principal geometrical plinth parameters are summarized in next figure below:

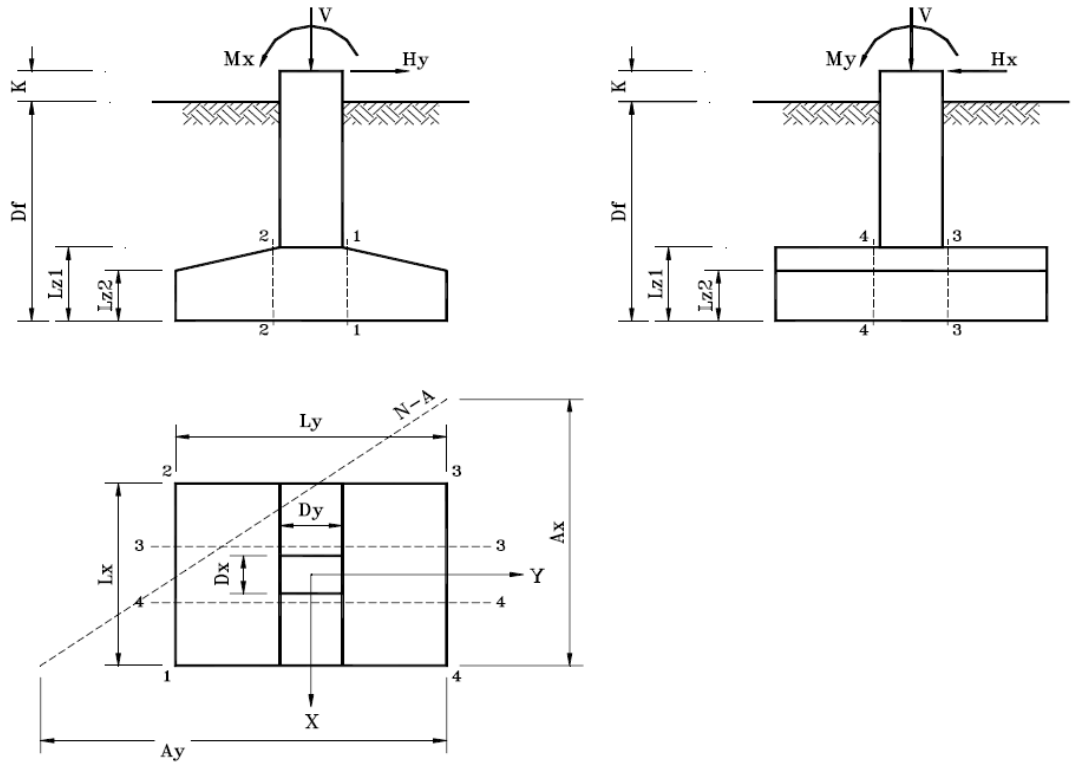


Figure 1: Principal Geometrical Plinth Parameters

2-4-2- Soil bearing capacities of mat foundations

The actual average pressure: $q_{max} = K_w S_{max}$

S_{max}: is the max value of displacements at the end of column of the foundations in SLS_ENV combination plus with the adverse effect of settlement load case.

2-4-3- Check soil bearing capacity:

+ qmax < 1.00qa (applied for combinations with dead and live loads – Case "1")
+ qmax < 1.25qa (applied for combinations with wind load – Case "2")
+ qmax < 1.38qa (applied for combinations with earthquake load – Case "3")

2-4-4- Sliding Check:

1.50 For case-1 (Includes Dead & Live Loads Combinations);
1.30 For case-2 (Includes Wind Loads Combinations);
1.15 For case-3 (Includes Seismic Loads Combinations).

2-4-5- For Uplift Check:

1.30 For case-1 (Includes Dead & Live Loads Combinations);
1.20 For case-2 (Includes Wind Loads Combinations);
1.10 For case-3 (Includes Seismic Loads Combinations).

2-4-6- Flexural and Shear reinforcement design

Plinths have been designed according to UPC-97 with every ULS combination.

Flexural design

Using M11 and M22 of ULS_UPC-97 combination to flexural checking.

Shear checking

One-way shear checking (only concrete)

Punching shear checking (only concrete)

2-4-7- Pedestals design

Pedestals have been designed according to UPC-97 Code with every ULS combination. Spreadsheet is used to check the pedestal section as a short column for axial compression/tension and biaxial flexure.

STATICAL SYSTEM

A general Approach for structural Design is based on the following parameters

- The statical system is simple & easy to analyze to accommodate the structure & Architectural functions.
- Basic and construction materials that is locally available.

2-4-8- Building description

The executive Building as a whole consist of steel structure frames with the following description:

1. Main warehouse building with area of 91.00m x 30.5m.
2. Admin building adjacent to the warehouse with two floors.
3. Hazardous store.
4. Electrical building and plant room
5. Generator plinth
6. incinerator pad.
7. Guard Rooms (#3).
8. Covered area for lunch and recreation.
9. Rainwater harvested water tank

2-5- VERTICAL SYSTEM FOR BUILDINGS

The vertical system is the system that can resist the lateral loads, such as wind and earthquake loads. The vertical system shall be adopted using a vertical bracing system starting from the foundation level up to the roof level.

2-6- FIRE RESISTANCE

The structural design shall be considered of maximum 2.0 hours Fire resistance for some items as per architecture design criteria and drawings. Fire endurance affects the reinforcement concrete cover and minimum thickness of concrete elements.

2-7- FOUNDATIONS

Foundation is recommended to be rigid raft foundation, strip & isolated footings connected together with ground beams. The slab on grade slab is designed to sustain all surcharge or rack loads in addition to the forklift. As stated in the geotechnical report, the allowable gross bearing capacity is 200 N/mm2 at 2.0 m depth, this depth is corresponding to a sand of SPT in the range of 22. However, in order to minimize the consequent settlement, the following is recommended:

1. Foundation is to be RC isolated footings to be found on isolated PC footings of 300 mm thick with protrusions from all sides of the same value.
2. The foundation level is to be ensured resting on the sand of refusal condition (SPT >50), which is located at a depth of 3 m to 4 m as per the boreholes presented in the report.
3. In case the foundation level will be located within the top sand of the relatively low SPT values (SPT of 22 or less), then over-excavation should be carried out for the entire area of the site till the level of the competent sand and a compacted structural fill layer is to be carried out till the foundation level.
4. The replacement soil is to be of well graded sand with fines content not more than 15%. The outcrop of the excavation could be re-used after carrying out the necessary tests to confirm its suitability (sieve analysis and Atterberg limits would suffice). The replacement soil to be carried out according to the project specs and should be compacted on sublayers of 250 mm thickness till the foundation level. Quality control tests are to be carried out on the compacted sand to ensure minimum dry density not less than 95% of the maximum dry density measured in a modified proctor test.

5. Noting the relatively low SPT values within the top 3 m (SPT = 14 or less), the slab-on-grade should be ensured resting on competent sand condition, otherwise soil replacement is to be carried out as described in item 3.
6. The contractor is to carry out his own confirmatory investigation to confirm the levels of the competent sand layer and define the corresponding relation with the foundation levels of the structure.

2-8- WATERPROOFING

All substructures shall be protected using two coats of oxidized bitumen or any other suitable insulating material according to the project specification as per geotechnical report.

3- ARCHITECTURE DESIGN CRITERIA

The Design is based on the following Building and Design Codes

- The National Fire Prevention Association code, NFPA.
- NFPA 230 Standard for the Fire Protection of Storage
- Zimbabwe Guidelines for good wholesaling practice.
- Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities.
- The International Building Code (IBC) by International Code Council.
- Department of Defense (DOD) - UFC 4-440-01 Warehouses and Storage Facilities.

According to National Fire Prevention Association code, NFPA:

- Walls Separating the Warehouse from the Office building should be 2 Hours Fire Rated.
- Walls of All MEP Rooms (Electric Room, Plant Room) should be 2 Hours Fire Rated.
- Hazardous Storage should be 2 Hours Fire Rated.

4- GENERAL LAYOUT