





# CONSTRUCTION MANUAL

Guide on sustainable construction techniques for Low-Cost Housing



52500-Construction Manual.indd 1 21/07/2022 4:29 PM

52500-Construction Manual.indd 2 21/07/2022 4:29 PM

# **CONSTRUCTION MANUAL**

### Guide on cost efficient construction techniques for low-cost housing

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52500-Construction Manual.indd 3 21/07/2022 4:29 PM

# **Table of Content**

1.	IN	itroduction
2.	В	UILDING PLANS – THE BUILDING ON PAPER
2.:	1	Site Plan
2.2	2	Floor Plan3
2.3	3	Elevations4
2.4	4	Sections4
2.4	4	Other Drawings
3.	Pı	ROCUREMENT OF MATERIALS5
4.	В	UILDING THE HOUSE
4.	1	Clearing Site
4.2	2	Bulk Earthworks and Excavations
4.3	3	Foundation5
4.4	4	Floors 6
4.	5	Walls
4.	5.1	1 Brick Types7
4.0	6	Roof
		1 Types of Roofs

4.7	Plumbing and Electrical	9
4.8	Finishes	9
4.9	Final Completion and Handover	9
5. O	OTHER CONSIDERATIONS	10
5.1	Firewalls	10
5.2	Building a Double Storey House	10
5.3	Consent from the Neighbours	10
5.4	Other Professionals in the Building Process	10
5.5	Incremental Building	1
6. A	NNEXURES	1
6.1	Annexure 1: The Role of the Local Authority and the Building Inspector	12
6.2	Annexure 2: The Building Plan Checklist	
6.3	Annexure 3: Building Consent Form	13
6.4	Annexure 4: The Inspection Form	14
7 R	URLIOGRAPHY	11

### 1. Introduction

This manual aims to provide a guideline to house owners and builders on good construction practices for safe and affordable housing. The descriptions in this manual follow the standards and regulations as set out by local authorities in Namibia to ensure quality and sustainable buildings. To build a house many processes need to be followed and many professionals are involved. Firstly, is the preparation of building plans followed by the procurement of the building materials and finally the actual construction of the building. These processes will be explained in detail in this manual.

### 2. Building Plans - The Building on Paper

The construction of a house requires a full set of construction drawings. These drawings are known as 'building plans' and they show the local authority how your house will look and with which material the house will be constructed with. The building plans also show the builder, the joiner, the plumber and the electrician how to build the house. Building standards differ depending on the local authority, therefore, it is very important to consult the local authority and ensure that the building plans are approved before construction begins.

Local authorities require a fee to inspect and approve building plans. They will also inspect the construction of the house at various stages to ensure that it is in accordance with the approved building plans. If the owner wants to extend their house after it is completed, they must submit new building plans showing the house's additions. Once the plan is approved, they can construct the extension. Each local authority requires a different set of drawings so it is very important to get the building checklist from the local authority that explains what should be included in the building plans.

A typical set of building drawings include:

- a) Site Plan a view of the plot from above
- b) Floor Plan a view of the house from above
- c) Elevations views of the sides of the house
- d) Sections a view cutting through the house showing the inside of the floors, walls and roof

Other drawings that a local authority may need are:

- a) Electrical Layout
- b) Roof Plan
- c) Pavement Section
- d) Sewer Section
- e) Window and Door Schedule
- f) Septic Tank and Conservancy Tank Plan and Section
- g) Coverage Table

Building plans are the building on paper. The plans will be used to show the materials and all the characteristics of the house. Always make sure that the plans are according to the regulations set out by the Local Authority.

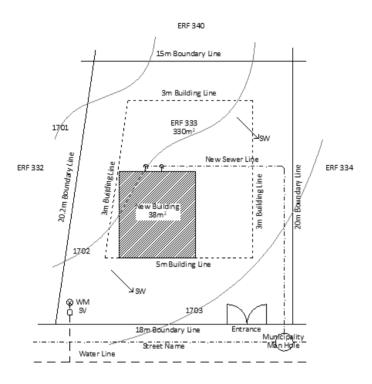


Figure 1: Typical Site Plan (by Author)

### 2.1 Site Plan

The site plan is usually on a scale of 1:200. The scales of drawings differ depending on the local authority one must verify with the building control department before submitting their plans. The site plan will show information such as the location of the house on the plan and how it is positioned, the dimensions (measurements) of the plot and the house and the distances of the house to the boundary walls, building lines, access into the plot, the topography (slope) and landscape, how the water and sewer pipes connect to the main municipality pipes and the manhole. Local authorities have different requirements, for example, building lines differ from town to town.

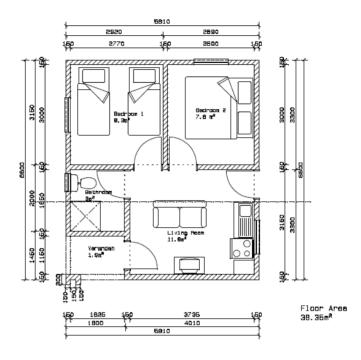


Figure 2: Floor Plans (DW Okahao Demo House)

### 2.2 Floor Plan

The floor plans are usually on a scale of 1:100. Floor plans show the rooms inside the building, the walls, doors and windows. The floor plan should be well dimensioned, clearly showing the size of rooms, walls and openings. Plumbers and joiners also use the floor plan to understand where the cupboards and the plumbing fixtures are. Each room must be clearly labelled with the floor finishes indicated and all structural elements such as beams, and columns indicated.

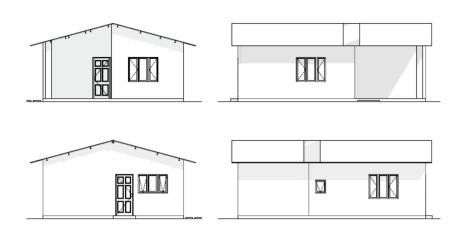


Figure 3: Building Elevations (Image by Author)

### 2.3 Elevations

All four elevations must be shown and clearly labelled either North, South, East or West Elevation. The main purpose of the elevations is to show the height of the building, exterior surfaces and windows and doors.

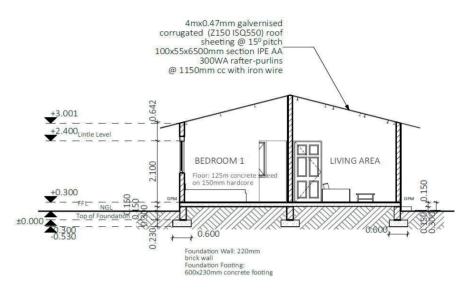


Figure 4: Building Section (Image by Author)

### 2.4 Sections

Sections are meant to show the inside of the building. It's a 'cut-through' of the building. The section is very important because it shows the materials used in construction. A typical section will show the depth and type of foundation, the floor from the ground level to the finished floor level, the thickness of the exterior and interior walls, structural support over openings and the roof, the ceiling, the beams and purlins and finally the roof materials and how all these roofing elements are attached. The section also shows the levels of the building. The key levels are the depth of the foundation, the natural ground level, the finished floor level, the lintel level (the top of the windows and doors), the ceiling level and finally the top of the roof.

52500-Construction Manual indd 7 21/07/2022 4:29 PM

### 2.4 Other Drawings

Depending on the municipality other drawings may be required. Drawings such as the electrical layout that shows all electrical features and how they are connected or the roof plan that shows the roof sheets and how they slope away from each other. The sewer section would show how each of the plumbing features is connected and how they connect to the manhole. The pavement section would show the relationship of the front of the building to the boundary wall to the pavement and the road outside. Other municipalities request a coverage table that shows the area of the site and the area of the house footprint.

### 3. Procurement of Materials

One of the purposes of a building plan is to assist in the preparation of a Bill of Quantities also known as a BoQ. A BoQ is a list of all the building materials that are needed to construct the building and in what quantities each material must be purchased. Once the BoQ is prepared the material can be purchased from local construction, building and hardware stores. In addition to the material cost, there is also the cost of transportation, therefore it is better to buy materials from nearby stores.

It is important to consider and prepare for the safe storage of the building materials once they have reached the site. If the owner of the house has employed the main contractor, then this is the responsibility of the main contractor on-site, but it is still important for the owner to consider the safety of the materials purchased. If the owner has contracted multiple subcontractors to do construction and has committed themselves to supervising the construction of the house, then the safekeeping of the materials becomes the sole responsibility of the homeowner.

### 4. Building the House

### **4.1 Clearing Site**

Before construction begins the site must be properly cleared to remove rubble and unwanted vegetation. At this stage, any trees that should be preserved during construction should be marked so that they are not damaged. It is also important that sanitary facilities be provided for the builders on site. Once the site is clear the construction parameters must be set out. If the site is level, then this means that the corners of the house are marked on-site to show where the house will be. If the site requires cutting and filling to level the site, then this must be done first before setting out.

### 4.2 Bulk Earthworks and Excavations

At times a site must be levelled and major excavation work, cut and filling, is required. The depth and soil type will determine the complexity of the excavation work and very complicated excavation should be done by a professional to ensure safety. Part of excavation work is the excavation of trenches for foundations.

### 4.3 Foundation

The purpose of the foundations is to evenly distribute the weight of the building to the ground. The ground is excavated according to the specifications in the building plans.

It is important to treat the excavated trenches with ant and termite poison before pouring the concrete for the footings to prevent infestation in the future. Concrete is usually mixed and poured. Once the concrete is set 220mm foundation walls are built just above ground level. The average depth of a foundation wall is 300mm to the top of the foundation, but this differs with local authorities and site conditions. It is very important to

5|Page

52500-Construction Manual.indd 8 21/07/2022 4:29 PM

ensure that the damp proof membrane, DPM, is laid so that ground moisture does not go into the walls.

If the foundation wall is higher than 1m it is important that the very second layer is reinforced for stability. Foundation walls may also act as reinforcing walls. These are walls that are designed and built to hold back soil, as such they should be stronger and waterproof. Once the walls are built the foundations are backfilled. Soil is put back in layers and compacted until the ground level is reached.

The foundation is the base of the building where ALL the forces of the building settle. It is important to make sure that the trenches, footings and foundations are inspected and approved by the local authority.



Figure 5: Foundation Trenches (setting out and foundations dug. (weebly.com))

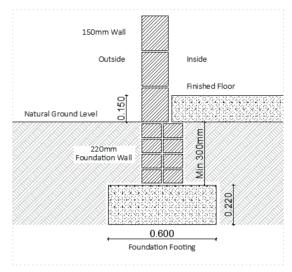


Figure 6: Typical Foundation Section (Image by Author)

### **4.4 Floors**

Typically, a concrete floor slab is 150mm thick. The specifications of the floor depend on the local authority, so it is important to ensure that the building complies. Usually, a floor is a mix of concrete, sand and aggregate. DPM must be laid to ensure that the floor is waterproof, and moisture is not taken up from the ground.

52500-Construction Manual indd 9 21/07/2022 4:29 PM

### 4.5 Walls

Once the floor is complete, construction of the walls to roof heights starts. To ensure that the walls are straight the corners are built first and the internal walls are built later. Openings for the windows and doors are left open. It is very important to ensure that the lintels are placed above the windows and doors so that the openings do not 'sag' or collapse inwards. For structural stability of the walls, it is important to include brick force at specific intervals in the layers of the bricklayers.

### 4.5.1 Brick Types

Super Brick 220x105x72mm



Block Brick 300x100x150



Hollow Brick 390x150x190



Figure 7: Brick types (cement-bricks-blocks - Jenkor and solid concrete block brick - Bing images)

Bricks come in different types, sizes and strengths. The most common brick is the 220x105x75mm super bricks. These bricks are strong and durable, and they come as face bricks that do not need to be plastered over and painted. More affordable bricks are block bricks or hollow block bricks. These bricks are larger and are more affordable but are less durable as compared to super bricks which is why these bricks should be plastered and painted. Some councils do not allow block bricks and hollow bricks to be used to build firewalls, super bricks should be used in this case.

52500-Construction Manual.indd 10 21/07/2022 4:29 PN

### 4.6 Roof

Once the walls are complete the next stage is to construct the roof. The roof construction should be according to the specifications in the section in the building plans. If the roof is made of timber, a carpenter will be needed and if it is made of steel the builder can continue the works, for complex roofs a welder is required.

### 4.6.1 Types of Roofs

There are different roof types, and they have different advantages and disadvantages. Some of the most common types of roofs in Namibia are the Open Gable and the Hip roofs (commonly known as diamond roofs). This is because these roofs have good drainage and water runs off the roof easily without gathering in one place.

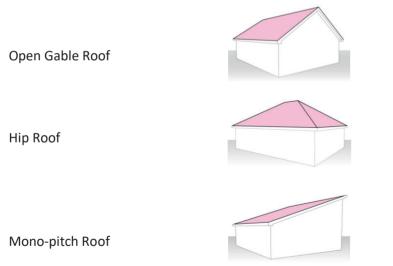


Figure 8: Roof types (Hip Roof vs. Gable Roof - Pros & Cons of Each Type (roofingcalc.com))

### 4.6.2 Types of Roof Sheets

Like different roof types there are different roof sheets to choose from. The two most common roof sheets are galvanised corrugated sheets and IBR sheets. Galvanised corrugated sheets are more affordable than IBR sheets.





IBR Sheets



Figure 9: Galvernised and IBR roof sheets (Galvanised Steel Corrugated Roofing & Cladding Sheet | corrugatedplasticroofing.co.uk and IBR Roofing Sheets – Syscot Electrical and Hardware)

### 4.7 Plumbing and Electrical

At this stage of construction, water and electrical PVCs can be installed into the walls. PVC pipes come in different thicknesses and diameters to fit different purposes. The plumber connects and lays the pipes according to the drawings and connects them to the manhole and main waterline.

It is very important to ensure that the electrician who installs the electrical wiring and fixtures should have a Wiring and Compliance Licence from the local electrical distributor. This is a matter of safety because faulty wiring can easily cause an electrical fire.

### 4.8 Finishes

Finishing a house is one of the final steps in the building process. Finishing a house is not only to make it look attractive but also to protect the building materials. The most common types of finishes on the walls of a house are plastering and painting. Plastering and painting a house protects the bricks from rain and wind. This is important especially if you use a block or hollow bricks that wear quickly. Super bricks are stronger, and they do not need to be plastered and painted if the owner wishes to leave them as is.

The other consideration is the material used for the window and door frames. The owner can choose either aluminium windows or standard steel windows. Standard steel windows are much cheaper than aluminium windows.

There are so many finishes to choose from, plastering, painting and face bricks. The choice of finishes on a house should be determined by what you like, what you can afford and what is durable and long-lasting.

### 4.9 Final Completion and Handover

Once the building is complete the building is handed over to the owner. The owner must thoroughly inspect the building to ensure that there are no defects on the building. Defects can either be minor or major and they should be corrected by the contractor or the builder. Minor defects are small and do not affect the structural stability of the building or the usability of the building, for example, chipped paint or a cracked tile.

Major defects however affects the main structure of the building and usually present themselves as large cracks in the brickwork, a plumbing system that is not working or other serious problems that affect living in the house.

Defects can also be latent or patent. Patent defects are obvious to see and can be identified immediately for example a cracked tile while latent defects may take time to present themselves. A common example of a latent defect is a leaking roof. If a house is completed in the dry season the roof may seem sound but when it rains months later it starts to leak, showing it was built incorrectly. The builder is required to fix these defects once they are detected.

The building inspector will also conduct an inspection at final completion to ensure that the building is built properly and according to the building plans.

Building a house is an investment. Do not hesitate to become fully involved with the process and with all the professionals involved.

### 5. Other Considerations

### 5.1 Firewalls

One of the key elements of a building is firewalls. Firewalls are important because they are walls that are placed in specific places to ensure that in the event of a fire, the fire will not spread too quickly throughout the house and to neighbouring houses.

Firewalls are supposed to be 220mm thick brick walls plastered and painted on both sides. Firewalls should be placed in key places, for example, between living units in a complex, between the garage and adjacent rooms, along a boundary wall if the house is built along the boundary wall or if the walls are built closer than 1.5m away from the next house.

Local authorities are very strict about firewalls because they ensure the safety of the occupants and neighbouring houses in the event of a fire.

### 5.2 Building a Double Storey House

Building a double-storey house is more complicated and more expensive than building a single storey house. The benefit of building a double-storey house is that it allows for higher density on smaller plots and leaves more space for the garden.

When building a double-storey house, it is important to make sure that the walls on the ground floor are 220mm thick super brick walls so that they can support the walls for the storey above. To ensure that a double-storey building is structurally stable it is important to get an engineer to draw structural drawings to submit to the municipality in addition to the drawings by the architect.

The more complicated the building, the more expensive it is to plan and build. Local Authorities require professionals to ensure that the buildings are safe for the owner and the neighbours around.

### 5.3 Consent from the Neighbours

It is important to get your neighbours' consent if you are building past the building line. This is because building past the building line your structure will affect their house, so they have the right to decide if you should build that close to their house. A neighbour gives consent on a municipal consent form as well as putting their signature on the plans that are submitted to the municipality.

### 5.4 Other Professionals in the Building Process

When building a house there are several professionals who are needed from the planning to the completion of construction. Usually, the first professional is the architect whose responsibility of drawing up the plans to submit to the municipality. Sometimes the architect will also continue working on the project making sure that the building is constructed according to the plans. Projects also require a structural engineer if the building is a double-storey building or if it is a complicated building.

A quantity surveyor's responsibility is to calculate the quantities of the building materials and the cost of the building. The larger the building the more the need to involve all the professionals in the planning phase.

During construction the contractor or the builder also requires professional skills such as an electrician, plumber and carpenter to help in the construction of the building.

Low-cost housing combines the skills of all the professionals in the planning phases to provide pre-prepared plans.

### 5.5 Incremental Building

Incremental building refers to the practice of building a house in small sections over a long period of time rather than building the whole house at once. When building an incremental house, it is important to take into consideration future construction. It is common to lay foundations and floors for future construction and to 'tooth' the wall that will continue to be constructed in the future.

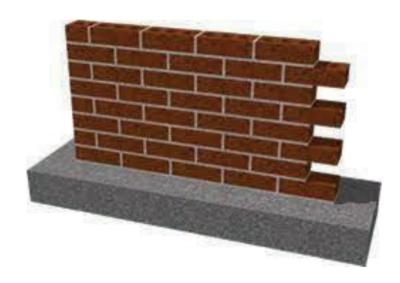


Figure 10: Toothing in a wall to continue construction at a later date (toothing in wall construction - Google Search)

### 6. Annexures

# 6.1 Annexure 1: The Role of the Local Authority and the Building Inspector

### Role of the Local Authority – Building Department

- 1. To provide building guidelines and a building checklist.
- 2. To approve building plans. If the building plans do not meet the requirements the building department of the local authority will request that changes be made before they approve

### Role of the Building Inspector in (Local Authority)

- 1. Once construction has started the building inspector will inspect the foundation depths and position to ensure that the building is within the boundary lines. The erf pegs must be clearly visible.
- 2. Inspection of the DPM in the foundations.
- 3. Inspection of open drainage before the pipes are covered up
- 4. Inspection after drainage is covered. Inspection of the plumbing fixtures and connection.
- 5. Inspection of door and window schedule
- 6. Inspections of room sizes being more than 7m<sup>2</sup>
- 7. Inspections on the quality control of the roof

## 6.2 Annexure 2: The Building Plan Checklist

GENERAL (APPLICATION FORM)		MINIMUM PLAN SIZ	ES: 4/A3 = A1			
f Number		Size of arches/openings		Special foundation - Cimbebasia & Prosperita, New Aca		Existing buildings all
uburb Name		Roof support @ demolished walls		FFL to ceiling height	Т	New buildings ( properly indicated )
escription of Plan		Selfclosing firedoors between house + garage		FIREWALLS (1: 100)		Existing sewer lines
reet Name		100mm step between house + garage		Section thru firewall	Т	New sewer lines
rea of building - existing		Sliding door size		Foundation inside boundary line	Т	Connection details (ss, vp, og, re's, lrb )
wner Full detail		Windows no's / codes / details		Parapet height ( 300 mm above roof level )		Distances :
rchitect Full detail		Windows 10% of floor area ( 5% to open)		THATCH (1:100)	Т	buildings to boundaries
XTRA		Boundary wall plan		Sprinklers - 2,25 L / min / m² or waterpoint within 3m		between buildings
ngineer's letter		Position of section		Firewalls on boundaries	Т	roof + windows min 1500mm to boundary
ngineer's plans		Storeroom maximum 15m²		Thatch exceeding 20m² to be 3 m from boundaries		Concrete encasing for sewer pipes under floors
eighbour letter of consent		Pool backwash to internal sewer		Thatch 20m² or less to be 500mm from boundaries	Т	Sewer Service ducts + access to ducts
ervice stamps		Engineering letter for pool closer than 1500mm to existing wall or build	ding	SEWER SECTION (1: 100)	Т	Thatch- Position, measurements & Firewalls
PLAN LAYOUT ( 1: 100 min )		ELEVATIONS (1:100 min)		Cover levels	Т	Neigbours signature on site plan
rea of new and scale		Headings - north, south etc. FFL on elevations, slope of ground on elev	vatio	Invert levels		BOUNDARY / GARDEN WALLS (1: 100)
cale of drawings		SECTION (1:100)		Fall ( slope)		Elevation, CJ + Spacing
se and areas of new rooms		Headings & scales		ss, og, re's, Irb, to be indicated	Т	Plastered & Painted Both Sides
ull details of first adjacent rooms		Section to be thru new building		Sewer pipe materials	Т	Section
emolishing - dotted lines - yellow		Roof covering - specify		Must be on scale	Т	Foundation inside boundary line
ross ventilation in rooms		Roof slope		SITE LAYOUT ( 1: 200 ) or (1:100)		Top of foundation on streetside to be 600mm
imensions of additions		Roof painted - certain areas		Erf daigram ( Surveyor-general )	Т	below street level
rewalls for buildings closer than 1500 mm		Purlins - sizes & spacing		Erf measurements, show from beacon to beacon		Indicate erf boundary on section
istance to boundaries		Trusses - sizes & spacing		Adjacent erf no's ( all )		Boundary wall plan
rewalls exceed buildings by 1500 mm	П	Rafters - sizes & spacing		Building lines ( 3m & 5 m )	T	PAVEMENT (1:100)
rewalls between house & garage		Wallplates - sizes		Contour lines	Т	Section thru pavement with levels
atch new walls + Colour		Brandering - sizes		Contour levels		Ramp 1:50 fall towards street
echanical vents & roof vents		Ceiling material - specify		Gates, sliding swing within property boundary		Pavement section for relaxation of 5m building lin
in. size of inhabitable rooms - 7m²	П	Roof supports - indicated		North point	T	PLAN SCRUTINZER:
in. internal dimensions of inhabitable rooms = 210		Ramp Details		Street name	Ī	ARCHITECT/DESIGNER:
tered rooms - total new area		Walls - hatch new		Mun sewer line & mun. waterline + manholes	Ī	DATE:
overage legend	П	Height - FFL to NGL min 150mm		Waterline ( new houses )	T	SIGNATURE:
	$\blacksquare$	Depth foundation - ngl to top of foundation min 200mm		Stormwater flow	1	KINDLY NOTE: SUBMIT THE ORIGINAL

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### 6.3 Annexure 3: Building Consent Form

Applicant:	Erf No.:	Tel. No.:
City of Windhoek		Department of Orban and Transport Planning Urban Planning Division

# **NEIGHBOUR CONSENT FORM**

coverage	
of	4
 Exceeding of coverage	Properties of anthonical
ä	(

Ä

COMMENTS REQUIRED FOR:

Signed:	Tel:	Date:	

\*Immediate neighbours include owners of properties that share borders or are separated by pan-handle accesses or small watercourses and public open spaces as well as those opposite across the street.

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City of Windhoek  Personant of Ultran Promise & Property Management	Inspection Report Received
	Name: Signature: Date:
NOTICE THAT THE FOUNDATION EXCAVATIONS ARE READY FOR INSPECTION	
Thereby give notice that the foundation excavation of the building on Erf No.:  No:  No.:	and the foundation excavation of the building on Erf No.:
the necessary sanitary facilities are available on site.	
The foundations excavations will be ready for inspection on	/ 20
NAME OF OWNER:	NAME OF BUILDER:
Checked:/ 20	Building Inspector:
NOTE: ANY PERSON BEGINNING TO ERECT A BUILDING IF INSPECTION SLIP IS NOT FILLED OUT C	NOTE: ANY PERSON REGINAING TO RECTA BUIDING WITHOUT GIVING NOTICE SHALL BE GUILIY OF AN OFFENCE. If inspection sup is not filled out completely, inspection will not be done
1	
Crif of Windmoek  Department of Ulban Planning & Property Management  Building Control Division	Inspection keport Received Name: Sgnature: Date:
NOTICE THAT THE DAMP PROOF COURSE ARE READY FOR INSPECTION	2
Thereby give notice that the damp proof course of the building on Erf No.:	):, Street:, Suburb:, Building Plan / 20
NAME OF OWNER:	NAME OF BUILDER:
Checked:	Building Inspectior:
City of Windhoek	Inspection Report Received
Building Control Division	Name: Sgnature: Date:
NOTICE THAT THE UNCOVERED DRAINS ARE READY FOR INSPECTION  I hereby give notice that the uncovered drains of the building on Erf No.:	NOTICE THAT THE UNCOVERED DRAINS ARE READY FOR INSPECTION  I hereby give notice that the uncovered drains of the building on Erf No.:
MAINE OF COMMERC.	NAME OF BUILDER.
Checked: / 20	Building Inspection: If inspection sup is not filled out completely, inspection will not be done.
City of Windhoek	Inspection Report Received
Building Control Division	Name:
NOTICE THAT THE DRAINS ARE READY FOR FINAL INSPECTION I hereby give notice that the dialnage of the building on Eff No:	4 AI THE DRAINS ARE READY FOR FINAL INSPECTION I'VE notice that the dialnage of the building on Eff No.:
NAME OF OWNER:	NAME OF BUILDER:
Checked:	Building Inspector:
City of Windhoek  Deportment of Ubon Planning & Property Management	Inspection Report Received
NOTICE OF COMPLETION OF BILLI DING	Notife:
Thereby give notice that the building on Eff No.:	I hereby give notice that the building on Eff No.:
NAME OF OWNER: Tel:	NAME OF BUILDER:

NOTE: THIS NOTICE MUST BE SENT IN BY THE PERSON RRECTING THE BUILDING WITHIN ONE MONTH AFTER COMPLETION OF THE BUILDING AND/OR SEVEN DAYS BEFORE SUCH BUILDING SHALL BE GUILTY OF AN OFFENCE. IF INSPECTION SUP IS NOT COMPLETELY, INSPECTION WILL NOT BE DONE

Building Inspector:

52500-Construction Manual.indd 17 21/07/2022 4:29 PM

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_building_plan_consents.pdf.
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52500-Construction Manual indd 18 21/07/2022 4:29 PM

52500-Construction Manual.indd 19 21/07/2022 4:29 PM





52500-Construction Manual.indd 20 21/07/2022 4:29 PM