PRECAST CONCRETE SLABS ON LOAD BEARING MASONRY WALLS

Good Practice Guide

CONCRETE MANUFACTURERS ASSOCIATION
Quality cast in concrete

INTRODUCTION

This technical note covers sound and accepted design and construction principles for masonry walls which support precast concrete slabs used for floors and roofs. As such the publication is aimed at the developer, the building professionals, architects, structural engineers, quantity surveyors and the builder. It is based on SABS standards for the types of materials used and required for design and construction. Each building situation is unique – these notes are guidelines for all those involved in the building process to determine optimum conditions – the balance of costs, ease and speed of construction, life costing etc.

BENEFITS OF LOAD BEARING MASONRY WALLS WITH PRECAST CONCRETE SLABS AS A BUILDING SYSTEM AND THE IMPORTANCE OF PREPLANNING

The use of masonry walls to support floor and roof slabs is not only based on its ability to carry safely the loads imposed but to provide the envelope that encloses the building. Building a structural framework to support the loads and then use exterior masonry infill panels, duplicates the structural requirement, increases costs and is time consuming.

In the interior of the building the use of structural masonry means that there is improved resistance to the spread of fire, generally an improvement in acoustic properties (less absorption and transmission of noise) and thermal comfort (improved capacity to store heat and reduction in heat movement) reducing insurance and operating costs of the building. Flexibility for possible re-arrangement of structural masonry supports can be improved by building in initially of continuous masonry bond beams at door/window height permitting some openings, say up to 2.0m in width, to be made at a subsequent date.

Also at the preplanning stage decisions should be made on imposed loadings on floors and roofs to be used in design. Though the building might initially be designed for office loading, say 2.5kN/m^2 it might be more economical, at some later stage to use the building for storage purposes with imposed loading of 5.0kN/m^2. Normally this would not require any major strengthening of the walls but requires the design of a stronger slab at a relatively small increase in the total cost of the building.

Initial planning can permit the accommodation and location of services (electrical, water, sewerage, etc) required initially and possibly in the future in optimum positions in the structure. In masonry walls horizontal chasing significantly reduces strength and is not normally permitted without special detailing. Installing suitable ducting is a possible answer to the problem. Holes in precast concrete slabs should be planned for, especially important in factory made slabs and beams. The coring of precast slabs has become a common and cost efficient procedure for any additional service holes that may be required. Control joints in walls must be in the same position in the slab.

The cost effectiveness of masonry/slab structures is in appreciating at the preplanning and design stage the advantages of the construction in reducing costs and time, improving the soundness and durability of the structure, and reducing initial operating and maintenance costs. The aesthetically pleasing façade of masonry buildings is an added bonus.

TYPES OF BUILDINGS AND ASSOCIATED ECONOMICS

The benefits of the use of precast prestressed slabs as compared to in-situ concrete are mainly quicker and easier construction, reduced site problems and supervision, greater confidence in the slab structure and better span to depth ratios.

Suspended slabs are suitable for use in all types of building e.g. residential, commercial, industrial, educational, recreational etc. Commercial office buildings often have a basement with the slab supported on a RC or structural steel framework structure based on a car parking module. Longitudinally columns are at 5m

(2 car) or 7.5m (3 car) spacing and transversally at say 7.5m spacing.

With hollow core slabs a guide to the relationship between thickness, span and type of structure is given in table 1.

A typical cost comparison of an office block (Johannesburg 2001/02) comparing a reinforced concrete frame of in-situ cast columns and beams supporting a post tensioned slab, with a precast concrete suspended floor supported on external masonry walls with internally in-situ cast concrete columns supporting reinforced precast beams is shown in table 2.

MAX SPAN, metres	THICKNESS, mm	NORMAL USE
6	120	Domestic building
7	150	Office loading / Domestic
8.5	200	School loading/Office
10	250	Offices
12.0	250	Roof loading + any of above

Table 1

	RC CONSTRUCTION	LOAD BEARING MASONRY AND PRECAST SLAB
Time required for construction, weeks	15	9
Cost, R	931 000	802 000
Note: The office block was 3600m² in plan and comparison covered basement, ground and first floor slabs as at June 2002.		

Table 2

SUSPENDED SLABS FOR FLOORS AND ROOFS: THE FUTURE

In South Africa an overall design consideration is to reduce costs in the building and operation of residential, educational, community and health, industrial and commercial buildings.

Low rise buildings, say up to three storeys where lifts are not normally required, increase the density in the use of land saving costs on services i.e. roads, water, sewerage, electricity etc.

Low-rise buildings of masonry construction use local material and are a traditional form of construction. Suspended slabs use readily available materials and techniques of construction that are cost effective, while the higher strength concrete used with increased prestressing can reduce the mass and handling of suspended slabs. The overall consideration in development is “buildability” – ease of construction, which reduce costs.

Future developments will involve better preplanning, construction planning, easier and firm access to site, cheaper and safer lifting equipment, better detailing of the beam/slab/wall intersection, while reducing site work to a minimum.

Suspended slabs on masonry walls is a recognized and proven system. It is time saving and economical. New technical developments together with improved construction management techniques will ensure that this is a sound and viable form of construction for the 21st century.

TYPES OF SUSPENDED SLABS

The hollow core slab (HCS) is a reinforced or prestressed concrete slab, containing cores, generally varying in thickness from 120mm to 250mm and, depending on loading, spanning up to 12m. The width is normally 900 or 1200mm.

A rib and block slab (RB) is composed of rectangular shaped (generally) precast concrete reinforced or prestressed ribs supporting rebated filler blocks placed between two ribs. This system is sometimes referred to as plank and block or beam and block. In-situ concrete is poured between and over the blocks. Slab depths vary from 170 to 380mm with clear span up to 10m. Beams with a width of 100–200mm and minimum depth 60mm are used with infill blocks 200–250mm long, 440 to 485mm width and 100–355mm deep.

The choice of which type of suspended slab to use depends on a number of factors and consideration should be given to the following.

The HCS is manufactured in the quality-controlled conditions of a factory and the only site work involved is the placing of a levelling screed 30 to 45mm thick. HCS fitting into non-modular widths (module normally 1200mm) are cut to size in the factory while concrete is fresh. HCS are cut to length to suit as built building dimensions immediately after the concrete has reached the required strength. Propping is usually not required on HCS and following trades can start work immediately after erection.

The RB system is more flexible in coping with irregular shapes. Spans are smaller and the lifting capacity required to place beams is less. It is significantly slower than HCS in construction time as in-situ concrete must be poured and cured. Propping of the system during construction is required with a RB system.

TYPES OF WALLS

Single leaf, collar jointed, cavity and diaphragm walls and walls with fins are suitable structural walls. Horizontal and vertical dimensions together with economic considerations will influence the wall type chosen. Single leaf external walls are normally 140–190mm in thickness and collar-jointed walls 190 and 230mm. With cavity and diaphragm walls (if the suspended slab rests on the inner leaf only) the external leaf is sometimes of face units 90, 110 or 140mm in thickness, while the inner leaf if supporting the slab, should have a minimum thickness of 110mm. Loading and the eccentricity of loading, and the slenderness ratio, vertical and horizontal, will dictate wall thickness. Hollow units are easier to reinforce both vertically and horizontally. Solid units can only be reinforced horizontally, unless the cavity of a cavity wall or special pockets are used to house vertical reinforcement.

DESIGN OF LOAD BEARING MASONRY WALLS AND PRECAST CONCRETE SLABS

Structural masonry walls give strength and stability to the structure. To ensure that the structure has satisfactory resistance to collapse, the layout arrangements of all components and their interaction to resist destabilising forces must be considered. Sometimes a designer will be responsible only for the structural masonry, or the suspended floors, or the roof. There should be a single designer responsible for overall design, including foundations and stability.

Structural components/elements of the structure should be effectively tied together such that in the longitudinal, transverse and vertical direction the whole structure is of robust construction. Consideration of the interaction between the masonry elements and other parts of the structure required to provide continuity is essential. The position of intersecting walls, piers and control (movement) joints must be assessed to ensure that they do not affect lateral stability adversely.

Overall masonry design covering accommodation of movement, design for stability, exclusion of moisture, fire resistance, thermal properties, sound absorption, sound insulation and noise reduction are covered in SANS 10021, SANS 10145 and SANS 10249.

Empirical structural design or design of reinforced masonry by simple rules have been developed by SABS (refer SANS 10400) and the National Home Builders Registration Council (refer Home Building Manual) where a rigorous design procedure is not warranted. They are normally conservative to ensure that the empirical design will have an adequate factor of safety against failure. Limitations and the type, size and wall configuration, which are covered in the design, are stated.

Rational design is based on assumed loading (SANS 10160) and resistance of the structural masonry to this loading (SANS 10164-1 and 2), codes of practice, which cover un-reinforced, reinforced and prestressed masonry. Suspended precast concrete slabs should comply with the requirements of SANS 1879 and the design code SANS 10100.

MATERIALS

Masonry

Masonry units, solid or hollow, brick or block size, of burnt clay or concrete of adequate compressive strength (usually 10.5 to 21MPa for solid units or 7.0 to 14.0MPa for hollow units) are satisfactory. Class II mortar (50kg common cement, 0–40 ℓ lime, 200 ℓ sand) is normally used. Fine and coarse aggregates should comply with the relevant SABS standard, particularly in respect of the fines content.

Precast slabs, ribs and blocks

Ribs, infill blocks and slabs should be manufactured to satisfy the requirements of SANS 1879. The standard specifies requirements for tolerances of dimensions of ribs, blocks and hollow core slab. The design and manufacture of ribs and slabs must ensure that under proof load the deflection, and recovery after removal of the test load satisfy the requirements of SANS 1879.

CONSTRUCTION

Masonry walls

Accuracy in the building of walls in the plan position to ensure satisfactory bearing length support for beams and slabs, and to the designated level (bedding joints thicker than 15mm reduce wall strength significantly) are vital for the success of the structure to perform its intended service. Packing pieces of fibre cement sheeting can be used under slabs or beams to achieve the correct level but gaps between shims must be filled with a suitable mortar mix. SANS 10155 covers accuracy in building and SANS 10164-1 states permissible deviations in accuracy for structural walls.

Hollow core slabs

Slabs are placed on the masonry walls with a minimum bearing of 100mm as per drawing details. On roofs or exposed balconies, install the specified material to accommodate thermal movement (e.g. bituminised softboard or similar). Such provision must make allowance for changes in camber or deflection, particularly where light parapet walls are built on prestressed HCS. In such situations a light mesh reinforcement should also be placed in the finishing screed or topping.

Rib and block system

Ribs are placed on the masonry walls with a minimum bearing of 100mm as per drawing details at approximate centres, their position being finally adjusted to suit the width of the filler block with a 35mm minimum bearing of block on rib. Closed end filler blocks are placed at the end of each line. Temporary propping of beams not exceeding 1800mm centres are erected to suitable level and camber. If transverse stiffener ribs are detailed then blocks are left out to accommodate reinforcement and concrete. Services should be installed over blocks and not ribs and the specified mesh is placed throughout. Before grade 25 (minimum) concrete is cast, all rubble should be removed and the blocks thoroughly wetted. Concreting should be continuous. Removal of the temporary propping before the compressive strength of the in-situ concrete reaches 17MPa will lead to an increase in the long term deflections.

Transport and lifting equipment

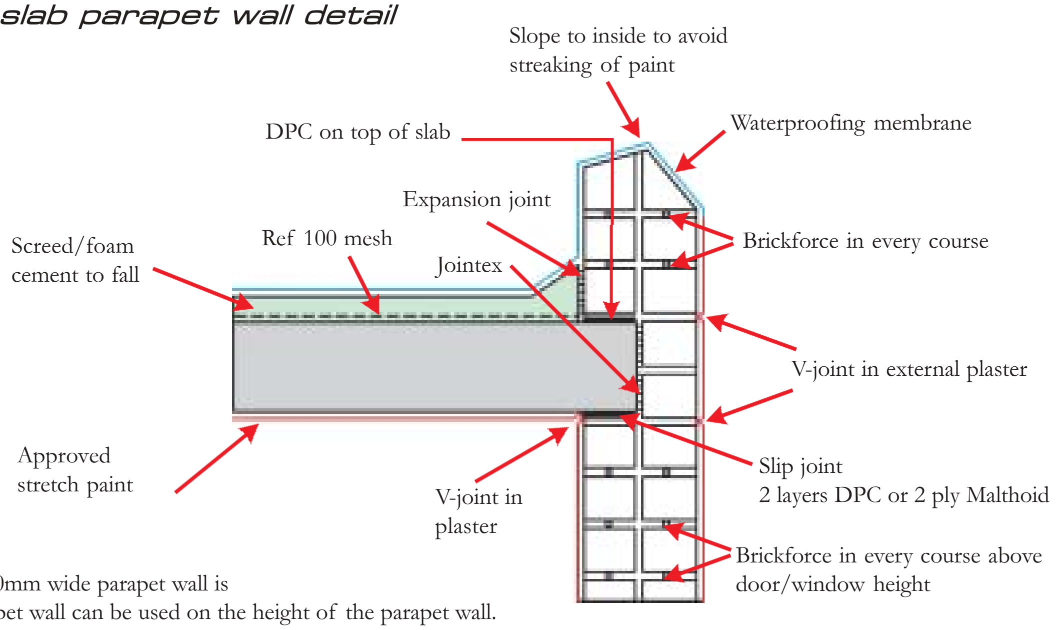
For HCS a crane is required to place the slabs into position directly from the delivery truck. Tower cranes give maximum reach but on normal 2 and 3 storey buildings mobile cranes are used. They have a lifting capacity of 30 tonnes with a 31m boom, and operate easily over a 17m radius. Larger cranes are available where required. With HCS the placing of 600m^2 to 700m^2 of finished floor area per shift can be achieved. With the RB system the ribs and blocks are usually stored on site and placed in position by hand when required.

Details of some intersections of masonry slabs

The connection between the masonry and the slabs is obviously critical to the structural strength, aesthetics and water resistant properties of the building.

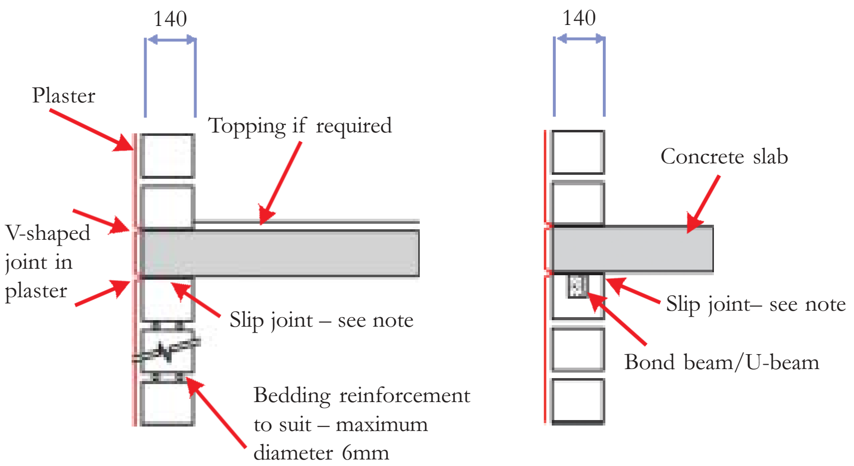
It is part of the role of the professional team in conjunction with the technical department of the manufacturer to develop details that best suit the needs of the various situations. A few of the typical details most commonly used follow.

Roof slab parapet wall detail



NB A 110mm wide parapet wall is
wide parapet wall can be used on the height of the parapet wall.

Suspended floors on external 140mm walls



NOTE:

1. If floor slab span exceeds 6m spanning on to wall and large movements expected consider a slip joint on top of wall, such as two layers of DPC or 2 ply Malthoid. Structural stability & robustness may preclude use of slip joint.
2. Consider use of U- or bond beams below slab.
3. If designer assumes wall laterally restrained by slab then slip joint not advisable.

TYPICAL MASONRY SLAB CONNECTION DETAILS

Control joints in walls and slabs

At the design stage the position of control joints, to reduce the likelihood of cracking due to movement (mainly due to temperature changes) is determined by the project engineer. Joints in slabs must coincide with the control joints in the masonry walls. Long lengths of freestanding walls are most susceptible. The addition of brickwork reinforcement and a concrete slab gives some restraint and the interruption of long facades by deep recesses also helps to reduce the incidence of cracking. The inclusion of a continuous reinforcing mesh in a screed or topping on a precast slab will increase the degree of restraint provided by the slab.

SUPERVISION AND INSPECTION

Supervision and inspection during construction will ensure that the final structure is of acceptable quality. This involves

- Ensuring walls built to acceptable plumb, line and level
- Ensuring position of holes or slots for services will not compromise structural integrity or durability.
- Adequate bearing length for beams/slabs
- Bearing surface is smooth and plane.
- Thickness of mortar joint is less than 15mm otherwise packing pieces to be used.
- Placing of ribs/slabs so walls are not damaged and ensure continuity of wall control joints into slabs
- Ensure that placing and compaction of concrete in a RB slab and structural topping in a reinforced hollow core slab is satisfactory. Prestressed hollow core slabs only require a 40mm levelling screed of river sand and cement. For guidance on the correct application of screeds and toppings see the C & CI publication "Recommendations for screeds and toppings".

Standards and references on precast concrete slab construction

SANS number	Title
50197-1	Common cement composition, specification and conformity
227	Burnt clay masonry units
1083	Aggregates from natural sources – aggregates for concrete
1090	Aggregates from natural sources – fine aggregates for plaster and mortar
1215	Concrete masonry units
1879	Precast concrete suspended slabs
10145	Concrete masonry constructions
10155	Accuracy in building
10100	The structural use of concrete
10160	The general procedures and loadings to be adopted for the design of buildings
10164-1	The structural use of masonry un-reinforced masonry walling.
10164-2	The structural use of masonry – reinforced and prestressed masonry.
10249	Masonry walling
10400	Application of the National Building Regulations

National Home Builders Registration Council's Home Building manual

Concrete Manufacturers Association publications:

Detailing of concrete masonry:	Volume 1	Solid units – 140
	Volume 2	Hollow units – 140/190
	Volume 3	Cavity wall – 240/290

Masonry manual – 2000

Structural concrete masonry. A design guide. F.S. Crofts and J.W. Lane

Some definitions

Masonry:	An assemblage of masonry units bonded together with mortar
Solid masonry unit:	A masonry unit containing cores not exceeding 25% of the gross volume of the unit.
Hollow masonry unit:	A masonry unit containing cores that exceed 25% but do not exceed 60% of the gross volume of the unit.

APPENDIX A

Accuracy in building masonry walls and manufacture of precast concrete suspended slabs

Masonry	
ITEM	**PERMISSIBLE DEVIATION mm**
Straightness, line	10 in 5m
Level, bed joints	± 5 in < 5m ± 10 in 5m to 10m ±15 in 10m to 20m
Plumb, vertical	± 5 in 3m ± 10 in 3m to 6m ± 20 in over 6m
Surface of supporting elements	— 10 + 5
Position on plan of any edge or marking measured from the nearest grid line or agreed centreline	± 10
Level (deviation) from designed level with reference to the nearest transferred datum of the average top surface of an element.	— 10 + 0
Bed joint thickness (normally 10 — 13mm) • First joint above supporting element (includes foundation)	± 3 — 5 + 10

Suspended slabs		
Tolerances on dimensions of ribs, blocks and hollow core slabs		
UNIT	**DIMENSION**	**TOLERANCES mm**
Rib	Length Width Depth	± 20 ± 3 ± 3
Block	Length Width Depth	± 5 ± 3 ± 3
Hollow core slab (full panel)	Length Width Width: splitter (a) Depth: 120 — 150mm 200 — 250mm	± 10 ± 4 ± 20 ± 5 ± 7
(a) A splitter is any slab less than the product standard width		

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