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Dial a House; - The Construction of Residential Buildings From Used Telephone Directories.

Category;
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Abstract.

Despite the expanding use of computers for the storage of information, the telephone directory continues as the major communication index. In Auckland there are in excess of 300,000 sets of three volumes discarded each year. If all were suitable, the resulting wall would be 2.4 m high and 5 km long.

Many recycled products require additional energy/materials to enable effective re-use. This paper reports on the work carried out to explore the use of this waste paper, utilizing it for wall elements with the minimum of re-working. Issues addressed are erection sequence, water, insect and fire resistance, and thermal, acoustic properties. Comparisons are drawn between buildings constructed from telephone directories, and those constructed from earth and straw bale. The progress of a house on Waiheke Island is discussed, with comment on regulatory requirements.

Introduction.

Paper products have been used in building construction for many years, and used in a variety of ways. Recycling of paper into building elements capable of supporting structural loading has been somewhat more limited. Examples range from cardboard cores in hollow core doors to the papercrete buildings reported by Solberg (1999) the use of cardboard tubes as structural elements proposed by Shigeru Ban (2004) to the use of waste news print as the main aggregate ingredient of ‘concrete’ blocks.

The major advantage of using telephone books as a wall element lies in the fact that this waste product moves to a new use without the need to re-form it. Consequently the energy requirements to achieve this new use are minimal.

Can walls constructed from telephone directories form part of the structural system of the building? Engineering analysis has been carried out to the structural viability of telephone book walls to resist vertical loading and to provide sufficient resistance for wind and earthquake.

This paper however, is concerned with the issue of *construction* in all its ramifications.

Physical Properties.

The Auckland area annually produces 300,000 sets of three books, the white pages in one volume, and the Yellow pages in two volumes.

| | | |
|--------------|------------------------------------|--------------|
| White pages. | 273mm x 215mm x 50mm thick, | 1.88 kg |
| Yellow pages | 273mm x 215mm x 39 or 36 mm thick, | 1.55-1.41 kg |

(Book sizes vary between years. Year 2002 were used for experimental work)

Method of Construction

In essence a phone book wall will be ‘laid up’ in much the same manner as a brick or block wall. The point of difference is that the width of the book is not a half module of the length. If a pure stretcher bond were to be used, then the books would need to be cut. This can be avoided (accept at window and door openings) by offsetting the books, as shown in **Fig 1**

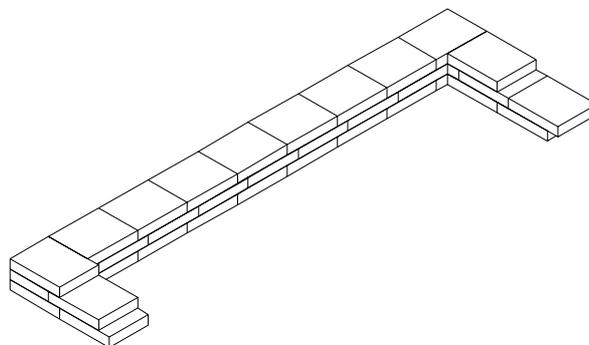


Fig 1

Connecting the books together.

The books will not stack, and remain as one unit without some means of vertical compression.

This can be achieved by

- 1) Passing a rod set in the foundations, through the middle of the book to a top plate and tensioning the rod via a nut, **Fig 2a**
- 2) Setting rods on both sides of the stack, and tensioning to the top plate as before. **Fig 2b**

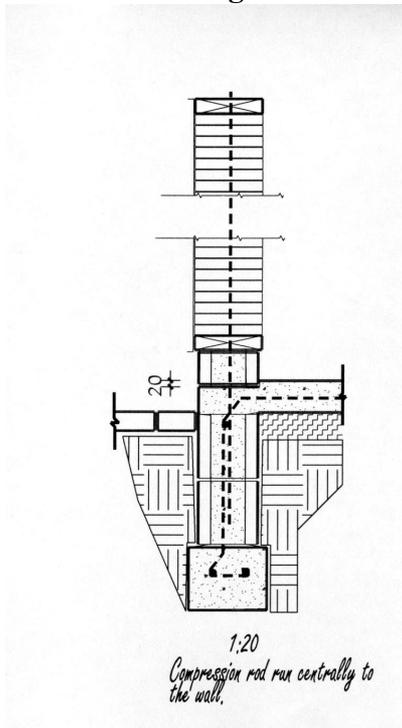


Fig 2a

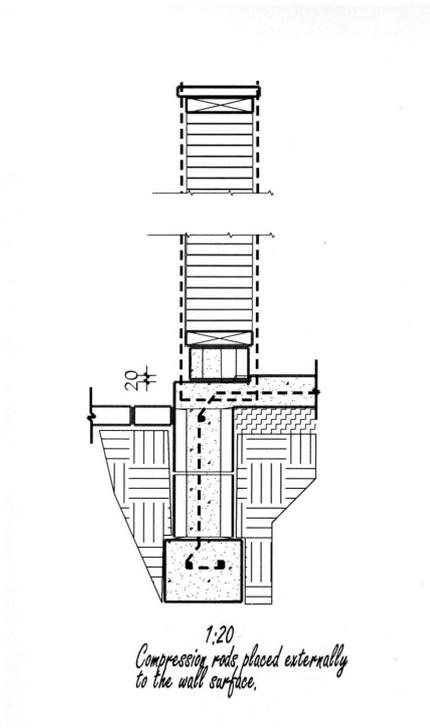


Fig 2b

Both methods have advantages and disadvantages.

The double rod solution provides a greater structural advantage to the wall when subjected to bending. Unfortunately, it does not allow the covers of the books to be glued in place while the wall is in compression. This pre-load is important as it takes up any shortening of the wall prior to the loads from the roof being placed on it. Failure to do so results in the surface being wrinkled when the load eventually comes on, consequently any contribution of the skin to the tensile resistance of the wall in bending would be limited. Connection at the base and the top of the wall is more difficult than the single rod solution, particularly at the base of the wall, where steel cover is important. However, if the rods were say galvanized channel sections, then it would be possible to attach cladding to them, which would form the basis of a 'drained cavity' solution.

The single rod approach has the advantages of using fewer rods, and more specifically, allowing the gluing of the coversheets, and their subsequent waterproofing, without restriction by the external rods. Unfortunately, as the rod is in the centre of the stack, it gives little support to the walls in bending, and it requires a hole to be drilled (or punched) through each phone book. This is not a major task, as a jig (**Fig 3**) can easily

be constructed to assist with this step. The same jig can be used to guide saws if the books need to be cut.



Fig 3

Erection sequence.

Telephone books are no different from many materials commonly used on building sites. They all must be protected from the weather by storing in a dry shed until required.

As would be expected the foundations and slab would be placed, with the vertical compression rods cast in prior to constructing the nib. To avoid water damage at floor level, the books would be placed on an ex 250x50 member which itself is placed on a concrete plinth, either cast into the slab or on top of one row of blocks. The main point to concentrate on is the location of the vertical rods that are to be passed through the books. With concrete block or concrete construction, the location of the reinforcing is not as critical as when the rods are to be placed through small diameter holes drilled through the books. For this reason, it is better to construct the upstand after placing the slab so that the vertical rods can be adjusted into final position. The bottom timber plate would be fitted over the rods and held some small distance above the plinth concrete is poured into the blocks forming the plinth.

Fig 4 shows the elevation of a wall, with the return wall to the left side, and an opening for a window or door to the right. Note that the width of the books are used to form the corner for the wall running away from the elevation, and cut books are used at the openings. Two hole locations are required in the books to accommodate for the offset of one layer to the next. In this example the vertical rods are no further than 810

mm on centre. It is not necessary for the rods to be tight into the hole, as there is no shear being taken by them. If the holes were oversize it would facilitate the stacking process, and avoid tolerance issues.

Not all books would need to be drilled, as can be seen in the elevation.

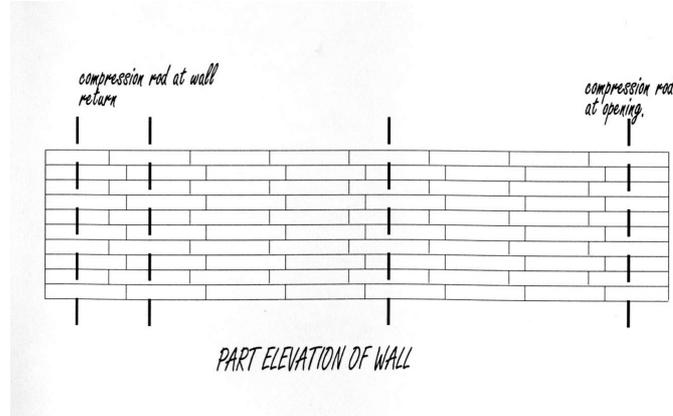


Fig 4

The wall would be completed and the top plate put into position. Tightening of the bolts to pre-load the walls would follow. The amount of compression is relatively small, even with a high pre load, and the amount of loss of pre-load over time is again small.

After two or three days of pre-load, the covers would be glued into place, followed by the waterproofing coat being applied. (experiments carried out on a 2.4m high wall demonstrated that creep as a response to loading was minimal after 2 to 3 days)

Water and Moisture proofing the wall.

As noted above the covers of the books would be glued together to form a continuous skin. The wall would be pre loaded and the covers successively glued to one another. Books would alternate so that the number of covers on each face would be equal. The covers could be glued together with a aliphatic PVA adhesive (Holdfast Manufacturing) that provides greater water resistance than the earlier generations of PVA adhesives. Over the outer face of the surface would be applied a coating such as Rainkote,(Duram Product 2004) a water-based acrylic which dries to a highly flexible UV resistant waterproofing system.

As the same size of timber member is used at the top plate level, vertical furring pieces to take a 'rain screen' cladding system may be firmly fixed at top and bottom, with intermediate fixing being formed by way of screws surrounded in adhesive and sent some 75 mm into the compressed books. Plaster finishes over rigid backing could then be selected, or weather boards, ply or other finish.

The resultant assembly provides for a drained cavity, taking any water entering the structure to below the line of the lowest book and the timber bottom plate that it is sitting on.

Fig 5 shows a section through the wall. The ceiling/roof structure is not indicated in this drawing, as different roof configurations will have different connections.

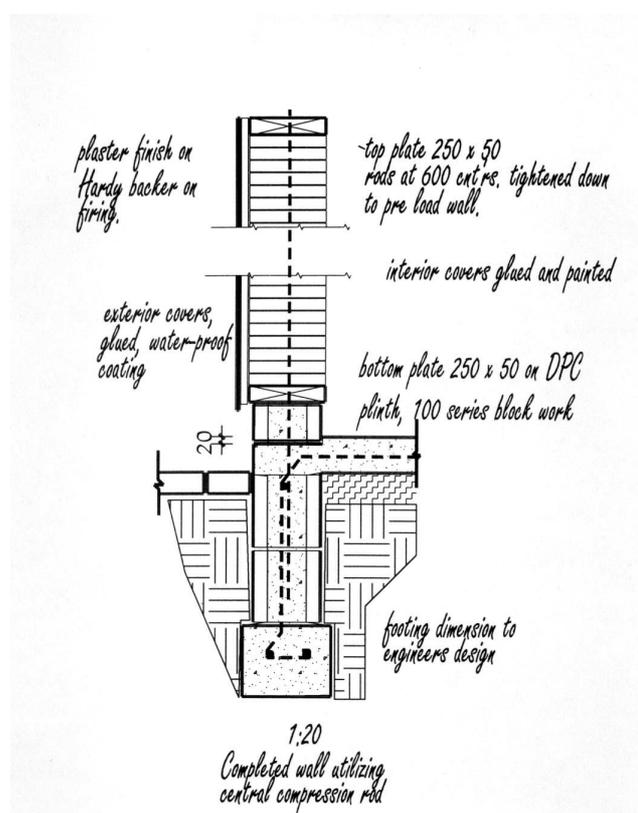


Fig 5

Openings, windows and doors

Corners as discussed above are achieved by off setting the books, producing a staggered 'stretcher bond'. As the return at a window or door opening is only the width of one book, it is necessary to cut the book on each alternate layer, turning down the covers and gluing as described above.

While it would be possible to generate a lintel within the wall surface, uneven compression may result. In a similar manner sills may present a differential compression problem. The proposals discussed here locate the lintel at the top of the wall with the opening being of full height. Depending on the width of the opening the depth of additional lintel would need to be constructed below and attached to the top plate. For uniformity of finish one could expect lintels of the same depth being used on all openings. The doors or window jamb would essentially support the lintels.

As with the wall surface generally the finish is returned around the corner and spaced off the furring pieces to provide the drained cavity.

Fig 6. Note the location of the jamb flashing.

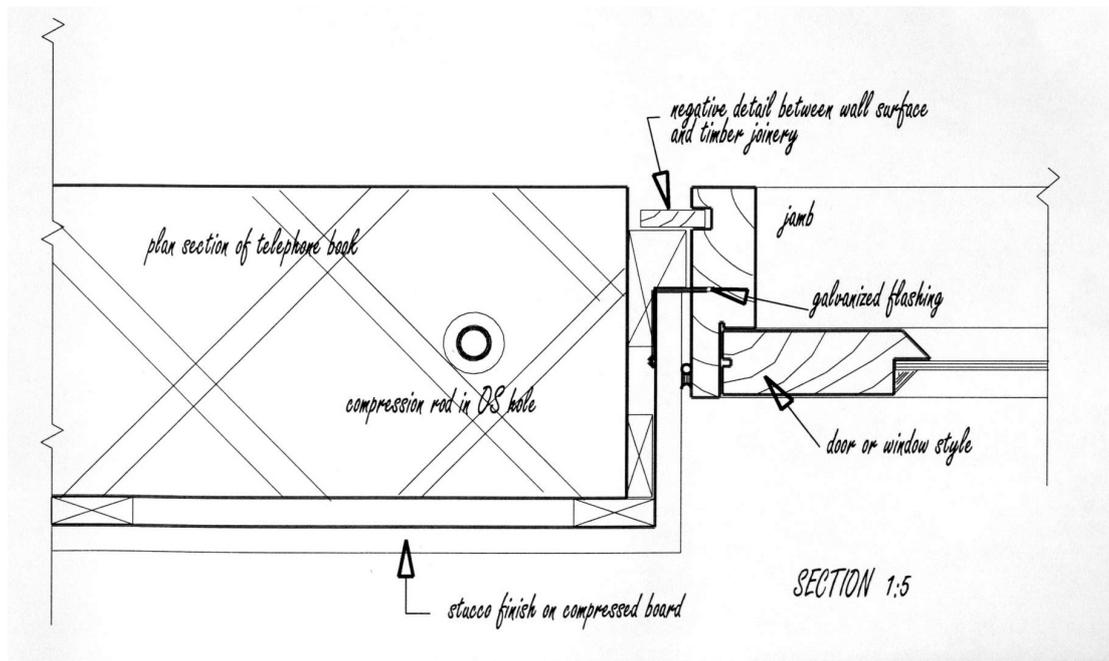


Fig 6 plan section

Service Rooms

Service rooms such as bathrooms and laundries would have their wall surfaces treated in the same way as the exterior wall. – water proof coating over laid with cement board on vertical furring. The cement board (7mm thick) would then take a tile finish. The upstand formed by the block plinth would provides for the flooring surface to be turned up the wall, finishing behind the cement board.

Reticulation of services

Phone and power services would be reticulated vertically via draw wires placed along side the compression rods. The holes through the books, as mentioned above, being oversized to provide sufficient tolerance would allow the cables to pass through them and to exit at desirable locations. Reticulation of water would be limited to pipe work run below the slab, exiting through the slab into the backs of units.

Sound transmission

Sound transmission through walls is influenced by a number of factors. Lightweight walls, typically timber or steel framed walls, permit the transmission of sound to a greater extent than heavy walls. This is particularly true of the low frequencies. The sound insulation software INSUL (Marshal Day Acoustics Ltd.) was applied to walls constructed of directories and compared with the 'standard' light timber framed construction. An STC: of 43 dBA was predicted and this was a marked improvement over a timber framed wall which is rated as having an STC: of 24 dBA. The timber wall's exterior face was sheathed with ex 20 mm weatherboards, or brick veneer, or 6mm cement fibreboard. Interior lining was 9.5 Gib Board and all cavities filled with fibreglass rating R1.8.

Fire resistance

Compressed phone books behave in a similar manner to laminated timber under fire exposure. With bulk timber the surface is destroyed slowly, approximately 1mm per minute. An unmonitored experiment with the phone books subjected to surface burning suggests a similar rate of loss of surface. (Sheng Li 2002)

Proposed building

Waiheke Island, North Island New Zealand

The author has been approached by a property owner on Waiheke Island seeking to construct a residential building utilizing telephone directories and building materials that are not preserved by the use of chemicals treatments such as CCA. This has meant that the materials selected are limited to those naturally insect and decay resistant. Primarily concrete and hardwood poles. The availability of old Jarrah telegraph poles provided for the structural system and Jarrah will be used for the top and bottom plates.

New Zealand Building Act, 1992

Prior to the introduction of the Act, building methods that were not prescribed by any building code were difficult to realise in a final built form. It was only possible to proceed if the construction had specific design information based on overseas examples and generally the building would be listed as experimental. While the construction methods have still to be proven, the current act provides clearly for 'alternative solutions', giving different approaches some legitimacy and consequently a building consent.

Conclusions

Buildings constructed utilizing discarded telephone books are viable and this method can meet the requirements of the New Zealand Building Act. Not all old books will be suitable, but there will be sufficient available to construct a significant number on an annual basis. Water damage during construction is the major concern. Good site practice, of protecting the books prior to their waterproofing is vital, but achievable. The construction process is labour intensive, rather than skill based, but care is needed when selecting the volumes and placing them into position. Services, power and communication can be accommodated within the walls, while it is preferable to run wet services within the slab.

This construction method is analogous to both earth and straw buildings, and in a similar manner is suited to the 'do it yourself' building owner/constructor who will not cost his own labour. It is informative to reflect that straw bales are plentiful in the South Island of New Zealand. To use them in Auckland requires additional cost of transport. It is somewhat similar for earth buildings. Frequently the 'earth' is moulded into blocks some distance from the building site using earth of a quality that is not available at the site. Large numbers of thick telephone books are available in Auckland. No so many in the South Island. Consequently, one thrust of building with alternative materials should be to source materials close to the building site.

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