Sewerage for low-income communities in Pakistan

by Kevin Tayler

Schemes involving local people and including on-plot improvements have introduced appropriate sewerage to low-income communities in Peshawar and Lahore.

ALL TOWNS AND CITIES in Pakistan, apart from Islamabad, include extensive areas which have been developed without formal planning or provision of services. The population density of such areas generally exceeds 300 persons per hectare when they are fully developed. In many cases an adequate water supply is available, either from private on-plot tubewells equipped with handpumps, or from the public distribution system. In these circumstances, pour-flush toilets and sewerage present an attractive option for sewage disposal. This article describes sewerage provision in Peshawar and Lahore, with particular reference to the St. Michael's Housing Society scheme in Peshawar and the North-east Lahore Upgrading Project. The first is a core housing scheme in which society members are provided with a plot, core room and sanitation block. About 150 housing units have been constructed since 1986. The second is a World Bank-financed scheme undertaken by the Lahore Development Authority with the help of consultants. To date, about 40 hectares have been upgraded or are covered by ongoing contracts. The project is intended to cover about 270 hectares over a six-year period.

This article is mainly concerned with technical aspects of the work. It examines the design and construction standards used, the measures adopted to minimize costs, and also looks at the subject of house connections.

Design and construction standards

Sewerage is often considered inappropriate for use in low-income communities because of the costs involved. In fact high costs are often the result of the use of inappropriate construction standards. The minimum allowable cover on the sewer has a particularly important effect on cost. This is largely because the small chambers required for shallow sewers are much smaller than conventional manholes. In fact, sewers can be laid to shallow depths where there is no heavy vehicular traffic. In the project areas, many streets are three metres wide or less, while few exceed five metres in width. Thus, there can be no heavy vehicular traffic and shallow sewers are possible.

Sewer depth

Two factors influence the sewer depth: the minimum depth of cover and the minimum slope allowed. In both schemes, the minimum depth to invert in streets and alleys carrying no heavy traffic is 500mm. This gives a cover of

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This open canal running through a slum in Jakarta provides neither fresh water nor an effective sewage system.

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A concrete path improves this housing area but the open drain remains.

about 250mm on a 230mm-diameter pipe and 325mm on a 150mm-diameter pipe. No problems have been encountered in either scheme with concrete pipes laid at this depth. Indeed, one 230mm-diameter sewer previously laid in North-east Lahore was exposed and found to be sound despite having been laid immediately under the 115mm-deep brick pavement. This pipe was probably not subject to any loading heavier than a motor-cycle or rickshaw, but there is no doubt that concrete pipes can be laid to shallow depths under roads carrying only light vehicular traffic.

The second factor affecting the sewer depth is the minimum gradient adopted. There appears to be no entirely satisfactory theory to cover the design of sewers near the head of a system which receives intermittent flows. Sinnatamby[1] argues for a minimum gradient of 1 in 167, based on the assumption of a minimum flush of 2.2 litres /second. The latter figure is high for a pour-flush system and ignores the effects of flow attenuation. Nevertheless, Sinnatamby reports that sewers laid to this gradient in Brazil and Karachi function satisfactorily. One previously laid length of sewer in North-east Lahore had a gradient of 1 in 800 and had been operating without problems for over a year. Inspection suggested that it might have been functioning as a long septic tank rather than a sewer! This would have long-term implications because of the danger that hydrogen sulphide produced in the sewer would cause deterioration of the concrete. In general, in both schemes, the aim has been to achieve minimum sewer gradients according to Table 1.

For larger numbers of houses, conventional theory is used. The subject of the minimum allowable slope on branch sewers is one which appears to merit further research.

Table 1. Minimum sewer gradients

Number of houses served	Desirable slope	Flattest allowable slope
Up to 5	1 : 100	1 : 125
5 - 15	1 : 120	1 : 125
15 - 30	1 : 140	1 : 150
30 - 50	1 : 160	1 : 170
30 - 100	1 : 180	1 : 180

Manholes

Shallow sewers do not require large manholes. In the North-east Lahore scheme, chambers with depths to invert up to 700mm, have plan dimensions of 500mm x 500mm or 500mm x 600mm. The longer chambers are used when two branches enter the chamber on one side. The chambers are built with half-brick thick walls of 115mm. For depths between 700mm and 1200mm, the chamber plan dimensions are 600mm x 800mm and the wall thickness is 230mm. These standards are adopted on the basis that depths up to about 700mm can be reached without entering the chamber, while dimensions of 600mm x 800mm permit the entry of a person. For greater depths, conventional manhole designs are used. The St. Michael's scheme uses 500mm x 500mm manholes up to a depth of over one metre. The UK Building Research Establishment recommends the use of 450mm x 450mm chambers up to an invert depth of one metre.[2]

Chamber covers in both schemes have been made by casting concrete into an angle-iron frame to which reinforcing bars have been welded. The 50mm-deep cover is located within an angle-iron frame fixed around the access opening. The major drawback of the framed covers is that they are expensive. The contractors' price for the smallest cover used in North-east Lahore is Rs.900, which is about 67 per cent of the total cost of the 500mm x 500mm chamber.

Another disadvantage is that, being relatively light, the covers are easily lifted. This statement may appear paradoxical since covers are intended to facilitate access, but our experience is that people tend to deposit solid waste in sewers when covers can be lifted easily. This is a particular problem in North-east Lahore and similar areas where solid waste collection services are poor and where the residents do not form a coherent group with direct involvement in the scheme. No design can completely eliminate this problem which must ultimately be tackled by education and provision of improved waste collection services. There is an argument, however, for using heavier covers without the angle-iron frame. This is the method universally adopted by individuals and private groups who construct sewerage to serve their plots or lanes. It is also the method used in the very successful Orangi Pilot Project. The main problem with unframed covers is that they tend to break at the corners. This should be preventable if some additional reinforcement is provided at corners.

Laying sewers

The pipes used in the St. Michael's scheme are plain-ended. A strip of hessian soaked in cement slurry is used to fill the joint between pipes. Cement mortar is then built up around the hessian to encase the joint. This system is widely used in private schemes in Pakistan but is not allowed on government jobs. Pipes with end sockets, costing roughly twice as much as the plain ended pipes, are used in North-east Lahore. No bedding is used in St. Michael's because the ground is firm. Brick ballast is used to bed pipes on the rather poor fill-soil found in North-east Lahore. A water level made out of a long transparent tube has been used to set sewer pipes to the required falls in St. Michael's. My experience is that this method can become inaccurate unless used carefully with all air bubbles excluded from the tube. Where a surveyor's level and staff are not available, it may be better to use a spirit level to lay pipes to falls. It would be interesting to receive readers comments on this.

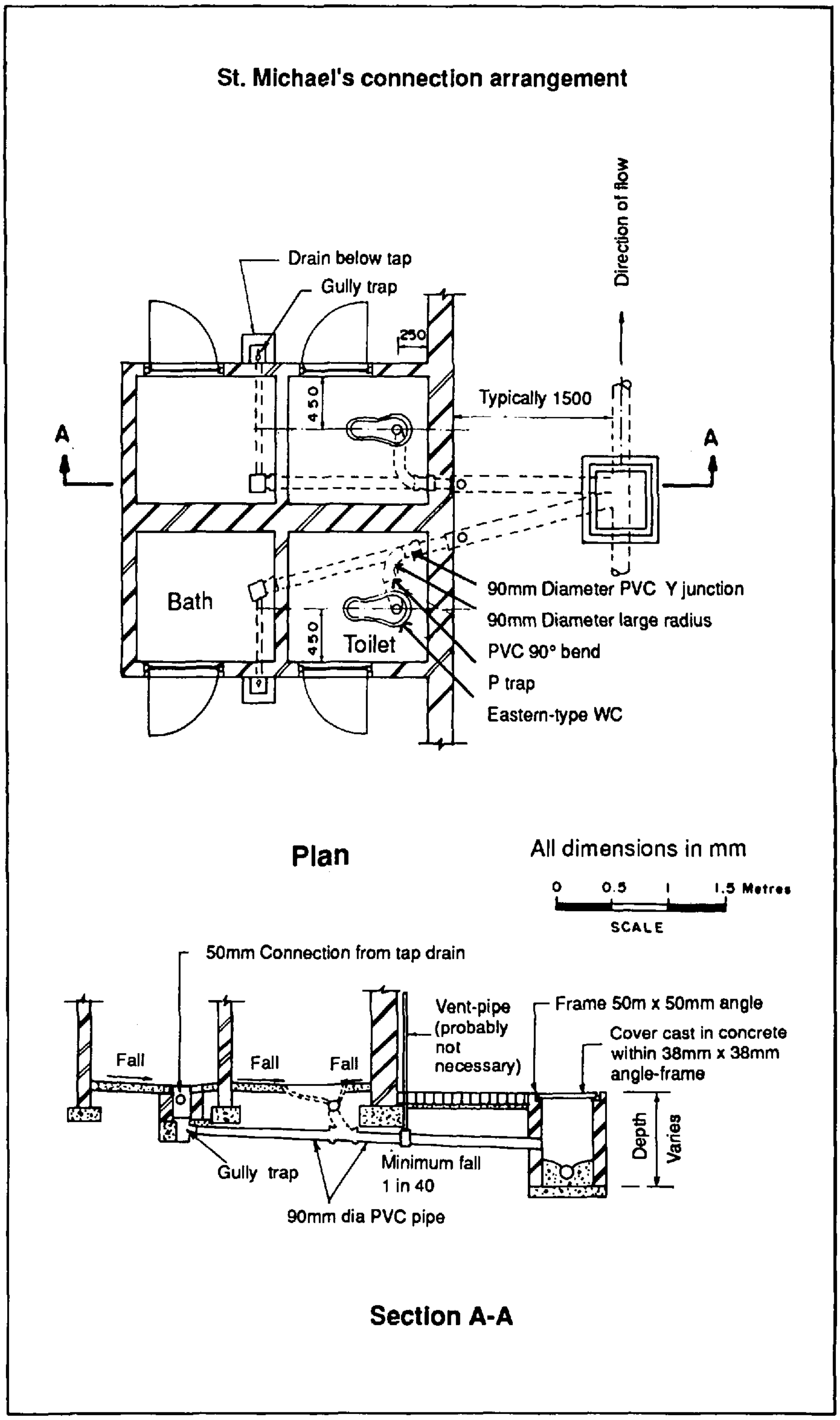


Figure 1. St. Michael's connection arrangement.

Pipe diameters

The minimum pipe diameter officially allowed in Lahore is 230mm. Although theoretically much larger than required for branch sewers, this size does provide considerable capacity to absorb the solid waste that finds its way into the system. Pipes of 150mm diameter are used without obvious problems in some streets in St. Michael's (see Figure 1) and some shared connections in North-east Lahore. It is interesting to note that residents of both schemes favour larger rather than smaller sewers and will comment that the sewers provided are too small.

Manhole spacing

The manhole spacing is determined by the length of sewer that can be rodded. Distances of at least 25m can be rodded with lengths of split bamboo wired together. We have not carried out tests on longer lengths.

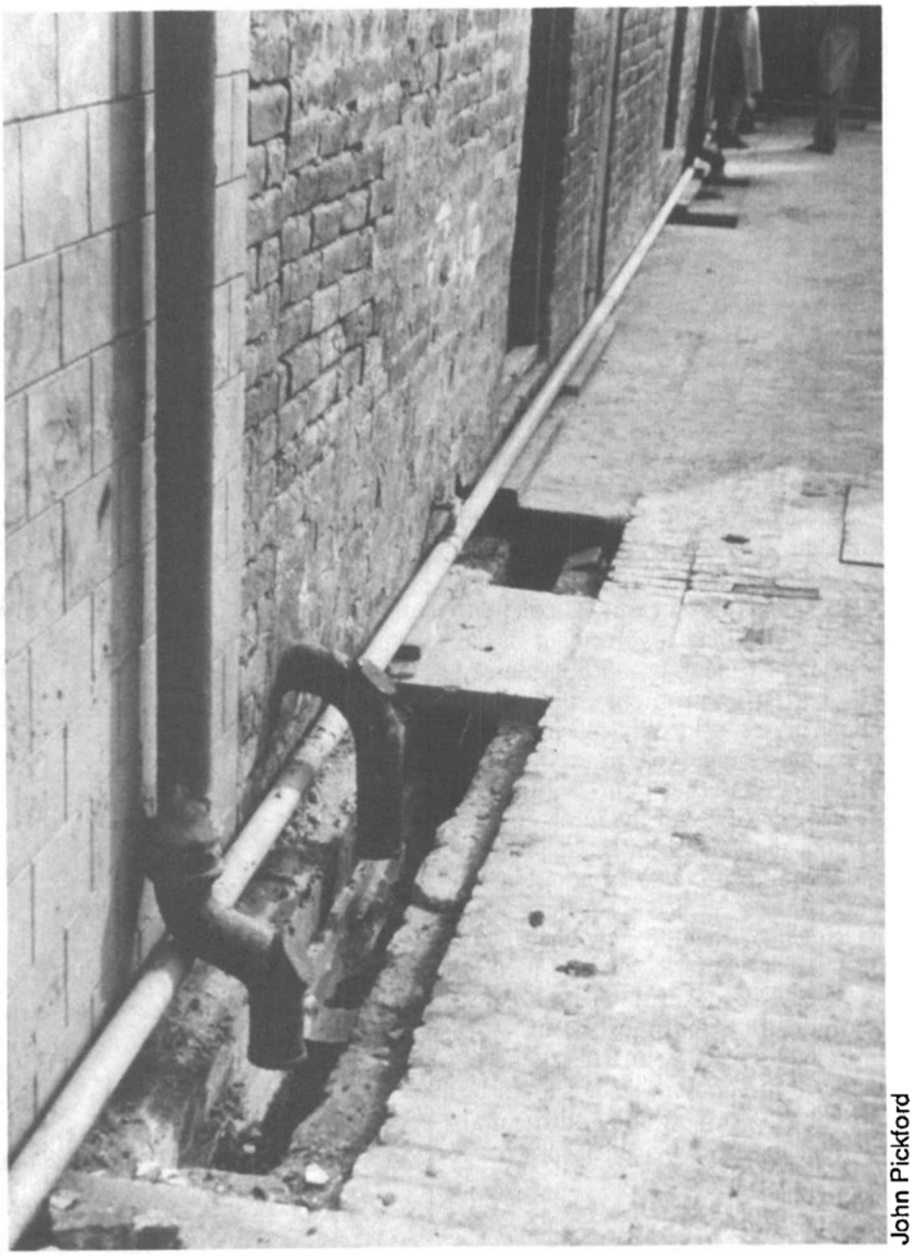
House connections

The two projects adopted different approaches to the provision of house connections. The philosophy at St. Michael's was to minimize connection costs by providing toilet/bathroom facilities at the front of the plot and employing an efficient pipework arrangement in the connection. Pipes inside the plot are 90mm-diameter PVC, and are manufactured locally. Immediately outside the wall, the PVC pipe connects with a 100mm diameter concrete pipe. The diameters of the pipes are such that the PVC pipe just fits inside the concrete pipe. Because the connections are short, reaching a maximum of about 4.5m for a 5m wide street, the design assumes that they can be rodded back from chambers on the main sewer lines. 500mm square chambers are provided at the junctions of connections with the main sewer, each chamber serving up to four connections. The connection pipes enter the manholes at a depth of under 500mm and are thus readily accessible for rodding. To date, no problems have been reported with connections and it seems that the smoothness of the PVC and the short length of the connections ensure that blockages rarely occur.

The cost of the pipework plus WC pan for each connection is around Rs.350. It is important that a connection is included from a point outside the bathroom to the trap on the bathroom drain. This will allow the disposal of kitchen wastewater and water used to clean floors. Where this connection was omitted on the early St. Michael's plots, people constructed open drains to the front of plots and either allowed water to discharge directly to the street or made a second connection to the sewer.

The collection point for waste flows may be located under the water tap so that any wasted water is discharged to the sewer. The experience in Lahore is that sand and ash used for scouring utensils tends to settle in sewers unless it is removed on plot. The collection point may therefore be a small chamber with its base below the outgoing pipe invert so that it will operate as a grit/grease trap. Although St. Michael's is a new housing scheme, the general principles that pipework should be simplified and combined wherever possible should also be applicable to schemes to upgrade existing housing.

A rather different approach to house connections was forced on the North-east Lahore scheme by its inability to ensure that on-plot improvements proceeded in parallel with the upgrading of public services. In order to minimize the future disruption it was decided that existing open-side drains in lanes would be retained and covered but modified to discharge into a central sewer at intervals. The reasoning behind this decision was that any future connections could be made to the side drain without breaking out the lane surfacing. Existing connections above ground level were improved where necessary by the provision of cast-iron bends or down-pipes. Once construction started, it was found that most drains had to be rebuilt completely because either the existing drain was in bad condition or it had inadequate slope. In later schemes, the drains were modified to allow them to flow in either direction to the nearest manhole. A further modification has been to replace the covered drains with 150mm pipes, serving up to about 4 houses. The minimum fall on these connections has been set at 1 in 100.



This side drain in North-east Lahore has its connecting pipes in place, but is still waiting for cover slabs.

Experience with the system suggests that it has its uses, particularly where falls are good or where connections along the sides of a short lane can eliminate the need for a central sewer. However, problems arise unless house connections are properly trapped. The drains and sewers become potential havens for rats, and it appears that flies may breed in drains where light is allowed to enter through untrapped connections. Perhaps the most important lesson is that there is no short-cut to improved sanitation. When sewers are laid people must be involved and on-plot improvements must form part of the work.

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Reference

1. Sinnatamby, *The Design of Shallow Sewer Systems*, UNCHS (Habitat) Nairobi, 1986.

2. 'Access to domestic underground drainage systems', *Building Research Establishment Digest*, December 1964.