## SETTLED SEWERAGE

## Part 2 of 3

| 1. | DESIGN EXAMPLE <br> Settled sewer to serve 10 compounds plus two future extensions: $L$ av. size $=24$ <br> 1. Serving a further 10 Water consumption compounds upstream $=70 \mathrm{lcd}$ of Station 10, and $\quad \therefore$ peak flow from <br> 2. Serving a further 20 each compound <br> compounds just $=1.5 \times 10^{-5} \mathrm{pw}$ <br> upstream of Station 7 $=1.5 \times 10^{-5} \times 24 \times 70$ <br> See chart...... <br> $=0.025$ litres $/ \mathrm{sec}$ | We are now going to look at a settled sewerage design example. We have to design a settled sewer to serve ten compounds plus two future extensions. The average family size of the compounds is 24 and they have a water consumption of 70 litres per person per day, so we can calculate the peak flow from each compound as $1.5 \times 10^{-5} \mathrm{pw}$ and that works out at 0.025 litres per second. One of the two further extensions is for ten compounds and the other for 20 compounds, and they discharge into the sewer at the points shown on this chart. |
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| 2. |  | On this chart we show our 10 stations which we divided the sewer into, and vertically we are plotting the elevation of each station above the datum level of station 1 ; and we are plotting horizontally the horizontal distance from station 1 . |
| 3. | DESIGN PROCEDURE <br> > Select sewer section for hydraulic analysis on the basis of each section having reasonably uniform gradients or flow <br> - Here nine sections are chosen <br> - hydraulic calculations given in Table..... | This is the design procedure we use: we select sewer sections for hydraulic analysis on the basis of each section having reasonably uniform gradients and flows. <br> Here we have chosen nine sections and the hydraulic calculations are given in this table. |
| 4. |  | We have ten stations, so therefore we have nine sections, and our calculations are done in 10 columns; and I am now going to describe each of these columns in turn. |


| 5. | Column 1 - Station number <br> Number given to point at which each section starts, commencing from downstream end of sewer <br> Column 2 - Station elevation <br> Elevation of each station above datum (taken here as elevation of Station 1) (m) | Column 1 is the station number, the number given to the point at which each section starts, commencing from the downstream end of the sewer. <br> Column 2 is the station elevation, the elevation of each station above the datum taken here as the elevation of station 1 , and it has units of metres. |
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| 6. | Column 3 - Distance <br> Horizontal distance of each station from Station 1 ( m ) <br> Column 4 - Elevation difference over section Difference between elevation of adjacent stations ( m ) <br> Column 5 - Section length Difference between station distances (Col. 3) of adjacent stations (m) | Column 3 is distance, the horizontal distance of each station from station 1, again in metres. <br> Column 4 is the elevation difference over the section - that is, the difference between the elevation of adjacent stations. <br> Column 5 is the section length - that is, the difference between adjacent station distances |
| 7. | Column 6 - Average section slope <br> Column $4 \div$ Column 5 ( $\mathrm{m} / \mathrm{m}$ ) <br> Column 7 - No. of connections served <br> Cumulative no. of compounds connected upstream of downstream end of section <br> Column 8 - Design flow <br> Peak flow in section (litres $/ \mathrm{sec}$ ) <br> $=$ Column $7 \times 0.025$ Peak flow per compound | Column 6 is the average section slope - that is, Column 4 divided by Column 5 . <br> Column 7 is the number of connections served and this is the cumulative number of compounds connected upstream of the downstream end of each section. <br> Column 8 is the design flow - that is, the peak flow in the section in $\mathrm{m} / \mathrm{s}$, so that equals the number of connections served (given in Column 7) $\times$ the peak flow per compound (which we have already calculated as $0.025 \mathrm{l} / \mathrm{s}$ ). |
| 8. | Column 9 - Sewer diameter <br> Diameter ( $\mathbf{m m}$ ) selected by designer for each section <br> $\square$ initial choice may prove to be inadequate \& pipe size may have to be increased <br> Column 10 - Flow at full pipe $Q=2.4 \times 10^{-4} D^{8 / 3} 3^{1 / 2}$ <br> column 5 <br> column 9 <br> eg, for Section 1, Q = 2.29 litres $/ \mathrm{sec}$ | Column 9 is the sewer diameter, the diameter in millimetres which we select for each section, and we have to realise at this stage that our initial choice may prove to be inadequate and the pipe size may have to be increased. <br> Column 10 is the flow at full pipe, which is given by this equation: $\mathrm{Q}=2.4 \times 10^{-4} D^{8 / 3}$ (where D is the diameter given in Column 9) $\times i^{1 / 2}$ (where $i$ is given in Column 6). For example, for Section 1 the flow at full pipe $Q=2.29$ litres per second. |


| 9. |  | Going back to the table, we do the hydraulic calculations for each of the nine sections, and then there are two things that we must check: firstly to see if our initial choice of sewer diameter was adequate or not; and then to examine what happens at any critical section. |
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| 10. |  <br>  | Looking first at the initial choice of sewer diameter, Column 9, and if we look at the section between stations 1 and 2, our design flow is $1 \mathrm{l} / \mathrm{s}$ and the flow at full pipe is 2.29 $\mathrm{l} / \mathrm{s}$; so the flow at full pipe is larger than the design flow - so this means that our choice of 50 mm for the sewer diameter was perfectly OK. |
| 11. | 1. Initial choice of sewer dia. <br>  | However, in two sections our initial choice of 50 mm diameter sewer is not satisfactory. These sections are between Stations 2 and 3 and between Stations 5 and 6 . In both sections the design flow is more than the pipe flow, and so we must use a 75 mm diameter sewer rather than 50 mm , and then in both cases the flow at full pipe in the larger diameter sewer is more than the design flow. |
| 12. | In two sections (2-3 and 5-6) 50 mm dia. pipe was too small and 75 mm dia. pipe had to be used * ```Note that, in both cases, the 75 mm dia. pipe discharges into a }50\textrm{mm}\mathrm{ dia. pipe This is NOT possible in conventional sewerage``` <br> * Design example done with initial choice of pipe diameter of 50 mm simply to demonstrate its hydraulic feasibility in practice a minimum diameter of 75 mm would be used throughout in order to permit easier sewer cleansing (should this ever be required) $>50 \text { mm dia. used in some schemes in USA }$ | In these two sections (between Stations 2 and 3 , and 5 and 6 ) we find the 50 mm pipe is too small and we had to use 75 mm pipe instead. In both cases it is worth noting the 75 mm pipe discharges back into a 50 mm pipe; and this is not possible in conventional sewerage, but is perfectly possible with settled sewerage. <br> This design example was done with an original choice of 50 mm sewer diameter simply to demonstrate its hydraulic feasibility. In fact we would use a minimum diameter of 75 mm as this would facilitate the cleaning of the sewer, should this ever be required. However, it is worth noting that in some schemes in the United States 50 mm has been used satisfactorily for many years. |


| 13. | 2. Critical Sections flat sections (none here) $\square$ pressure flow: <br> - here three sections: <br> - stations 3 to 4 <br> - stations 6 to 7 <br> - stations 9 to 10 <br> MUST AVOID BACKFLOW FROM SEWER TO INTERCEPTOR TANK | The second thing we have to look at are the critical sections: flat sections, and there are none in this example, and the sections in which the flow is pressure flow, and here there are three sections - between Stations 3 and 4 , between Stations 6 and 7, and between Stations 9 and 10; and in these sections we have to avoid the wastewater backflowing from the sewer to the interceptor tank. |
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| 14. | Three sections under <br> pressure flow <br>  | This slide shows the hydraulic calculations table again and the three sections under pressure flow. |
| 15. |  | Taking the section between Stations 6 and 7 as an example, we can calculate that the hydraulic gradient over this section is 0.012 and that it rises 0.89 m above Station 7 which is the upstream end of this section. |
| 16. | $\square$ calculate the hydraulic gradient for the section of sewer when flowing just full: $\begin{aligned} \mathrm{Q} & =2.4 \times 10^{-4} \mathrm{D}^{8 / 3} \mathrm{i}^{1 / 2} \\ \text { ie, } \quad \mathrm{i} & =\left(1.736 \times 10^{7}\right) \mathrm{Q}^{2} \mathrm{D}^{-16 / 3} \end{aligned}$ <br> eg, for section between stations 6 and 7, $Q=0.90$ litres/sec (Column 10) and D chosen as 50 mm , so: $\mathbf{i}=0.012 \mathrm{~m} / \mathrm{m}$ | First of all we calculate the hydraulic gradient across the section of sewer when it is flowing just full. This is the equation for $Q$, which we have had before, and we rearrange this in terms of $i$. For example, for the section between Stations 6 and $7 Q=$ $0.9 \mathrm{l} / \mathrm{s}$ and that is given in Column 10. We have chosen D as 50 mm , so $i$ is calculated as $0.012 \mathrm{~m} / \mathrm{m}$. |


| 17. | calculate max. elevation to which hydraulic gradient rises: $=0.012 \times 74=0.89 \mathrm{~m}$ above upstream end $\qquad$ $\qquad$ Hydraulic gradient Column 5 (section length) <br> TO AVOID BACKFLOW the invert of outlet of any interceptor tank must be above hydraulic gradient | Then we calculate the maximum elevation which the hydraulic gradient rises: so, that is the hydraulic gradient $0.012, \times 74$ which is the section length given in Column 5; and that works out at 0.89 m above the upstream end, which is Station 7. |
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