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Estimation of Probable Peak Load on Drainage System in Multistorey Office Buildings

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The drainage system in developing countries like India is designed on the basis of probable peak flow and discharge unit relationships as presented in the British Standard Code of Practice (B. S. C. P). or National Plumbing Code (N. P. C.) of U. S. A. Since the use of appliances in various countries are markedly different, depending on several factors e. g. climatic conditions, user's habits, configuration of appliances etc., this often leads to inefficient design of system.

The present paper describes in brief the work of developing discharge unit relationships for office buildings with recourse to a field survey under Indian conditions of usage so as to put forward a more realistic design peak load in similar tropical countries. Loading weights (discharge unit values) have also been assigned to different sanitary appliances.

Introduction

The drainage system in multistorey office buildings may have to receive discharge loads from various types of sanitary appliances, e. g., water-closet (W. C.), wash basin, urinal etc. Designing the pipes for hydraulic load assuming all the fixtures are under operation at the same instant will result in over design. It is, therefore, necessary to work out the probable peak load created by the simultaneous use of fixtures. Hunter (1) put forward a method of expressing the relative load producing effects of various sanitary appliances in term of fixture units (discharge units), which depend partly on the frequency of use of the appliances, and the pipe flow capacities are represented in terms of these units. The same fixture (appliance) may have different discharge unit values for domestic and office buildings. Griffiths (2) reported discharge unit values for appliances in public installations based on frequency of use, flow rate and duration of discharge from the appliances. Developing countries, in the absence of information based on experimental study, are adopting the relevant data, for design purpose, from the U. S. National Plumbing Code (NPC) and the British Standard Code of Practice (BSCP). Since the uses of sanitary appliances in different countries are markedly different depending on several factors, e. g., climatic

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conditions, user's habits, configuration of appliances etc., the data available in NPC or BSCP often leads to inefficient design of the drainage system. An attempt has, therefore, been made to assign loading weights (discharge unit values) to different sanitary appliances and to establish the relationship between discharge units and probable peak flow rates in multistorey office building under Indian conditions of use.

Prediction of Probable Peak Load

If a sanitary appliance has repeated cycles of use in which it is under operation for an average time 't' and the average interval between uses is 'T' the probability of the appliance being on at any instant is P=t/T and probability of being off at that instant is (l-P). Probability of 'r' or more appliances being on from a total number of 'n' such appliances is :

$$\sum_{r=r}^{r=n} nC_r \, P^r (1-P)^{n-r} = \sum_{r=r}^{r=n} nP_r \text{ (Say)}$$

Hunter (1) formulated the design method for pipe system based on criterion of limited failures. If a group of 'n' sanitary appliances does not give adequate flow when more than 'r' are in operation simultaneously, the portion of time the service remains unsatisfactory (i. e. the system fails) is represented by :

$$\sum_{r=r}^{r=n} nP_r = \text{Failure Rate} = \frac{1}{\zeta} \quad \dots \quad (1)$$

Assuming that the system fails for one second in ζ seconds. The relationship (Equation 1) forms the basis of a design procedure such that knowing the total number of sanitary appliances in a system, the probability of that appliance being on 'P' and the standard of service required (i. e. failure rate $1/\zeta$). the value of 'r' can be calculated. Design flow is achieved multiplying 'r' by the flow rate of respective appliance. In practice, more than one type of appliances are installed with drainage system and the probability of use of each appliance is also different. Since peak hours of use of different appliances rarely coincide, summation of design loads computed separately for each kind of appliance will give rise to over-estimation. Hunter (1) put forward the idea of assigning a loading weight or fixture (discharge) unit value to each kind of appliance.

In the present work relationship have been derived from equation (1) for different numbers and types of appliances, using appropriate values of probability (worked out based on actual field survey) but assuming a common failure rate equal to 0.01 (1.0 per cent).

Materials and Methods

Survey was conducted in 3 office buildings, 6 storey high, in Delhi to assess use frequency pattern of sanitary appliances during the peak summer months (i. e. June-July). These buildings were almost identical secretariate offices observing working hours 10.00 A. M. to 5.00 P. M. with lunch break from 1.00 P. M. to 1.30 P. M. for 6 days in a week. There were 2 categories of toilets: Staff toilets (having 3-w.c. with 12.5 litre high level flushing cistern, 3-washbasin and urinal with 4-stalls served by 4.5 litre tank and officer's toilets (having 1 w.c. and 1 wash basin). In the present study toilets having maximum use conditions were surveyed.

Use frequency and time of use of each appliance separately and also system as a whole the full working hours were studied with the help of water detectors and strip chart recorders. Sensors (two nickel coated metal electrodes) were inserted in the conduit through which water flow was to be detected. Insulator sleeves were provided to separate electrodes from the body of the conduit. These electrodes were connected to recorder via flow detector which is basically an amplifier. Electrical impulses produced by change in resistance in between the electrodes were recorded after amplification in the detector at the time of flow in pipe.

Each toilet was studied for a minimum of 3 consecutive working days to have reliable and reproducible data.

Results and Discussions

The drainage system in office building mainly receives discharges from w.cs., wash basins and urinals and sanitary appliances of each type are usually located in ranges. Peak hour of use of w.c., in 3-almost identical multistoreyed offices in Delhi, was observed to be during 12.00 noon and 1.00 P. M. prior to lunch break and the maximum number of uses recorded during that period was 13 for staff toilet (having 3 w.cs. in a range). Frequency of use of w.cs. during the critical day and the hourly probability of use have been observed. In the calculation of interval between discharges of a single appliance out of total number of uses per range, it has been assumed for simplicity that there was no preferential use of any particular appliance and the entire load is evenly distributed among the appliances in the range. Duration of discharge, the interval between discharges, probability of use and peak discharge of various sanitary appliances in the office buildings are presented in Table-I.

By applying theory of probability as discussed earlier, number of appliances r which may discharge simultaneously out of total number of a particular type of appliances was worked out. Relationships between probable peak flow and the total number of appliances, derived separately for urinal, wash basin and w.c., have been presented in Fig. 1 (peak discharge rate of various appliances were used as given in Table-I). Relative load producing effects (loading weights or discharge units) of difference sanitary appliances have been obtained by noting the number of appliances of each type (using Fig. 1) required to produced a chosen probable peak flow. For example, a peak flow of 200 lpm is probable from 180 urinals or 55 wash basins or 30 w.cs. (with 12.5 litre high level cistern) such that loading weight at this load are in the ratios of 1:3, 3:6 assigning a loading weight of 1 for urinal. This procedure was repeated for several other selected probable peak flows and the relative average loading weight (discharge units) determined are 1:3:6 for urinal, wash basin and w.c. respectively.

After assigning the discharge unit values to different sanitary appliances design curves were derived for soil and waste pipe in office buildings. Fig. 2 shows the relationship developed between discharge units and probable peak flow.

TABLE I – PROBABILITY OF USE AND PEAK DISCHARGE RATES OF VARIOUS SANITARY APPLIANCES IN OFFICE BUILDINGS

Sl. No.	Appliance	Duration of Discharge, t (seconds)	Interval between discharges T (seconds)	Probability of use P = t/T	Peak discharge rate (lpm)
1.	Urinal	10	600	0.0167	27
2.	Wash Basin	—	—	0.1840*	12
3.	W. C. with 12.5 litre high level cistern	12	831.4	0.0144	110

*Maximum hourly probability of use.

N. B. : Office lavatory basins in Indian Conditions are used for washing purposes under running taps with no splash situations.

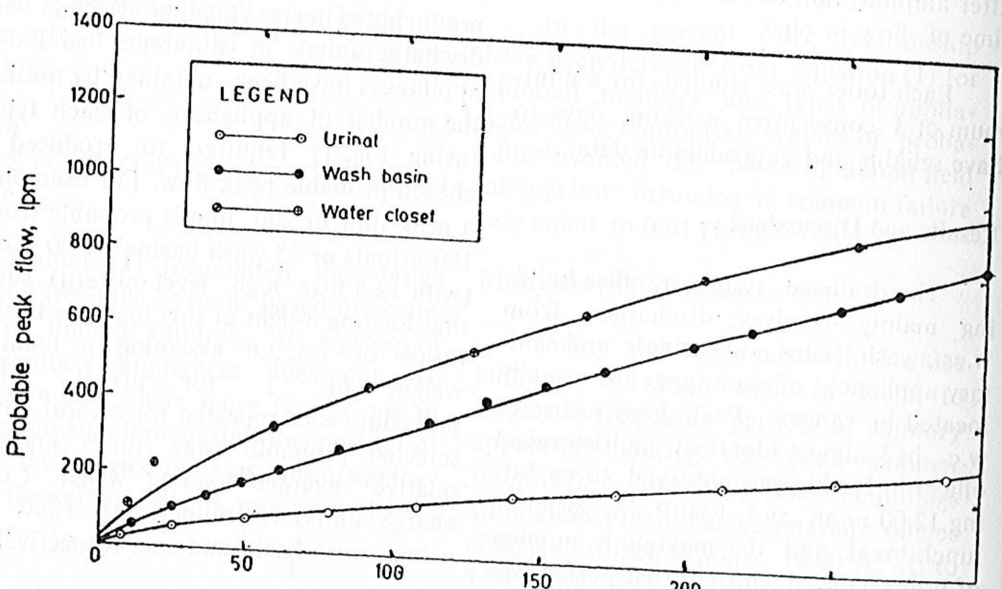

Fig. 1–Probable peak flow from various appliances

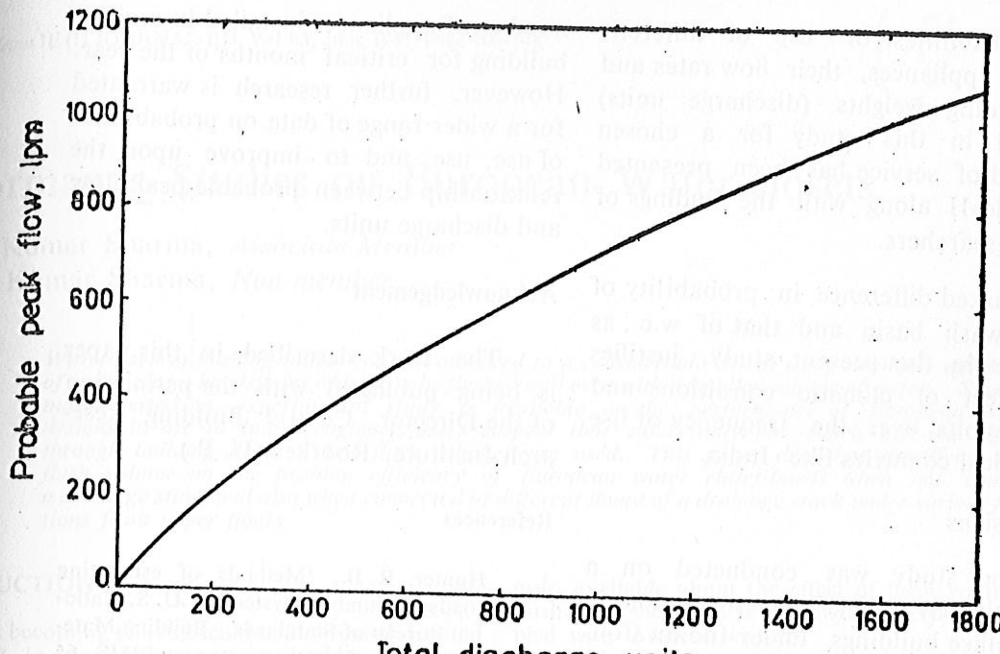

Fig 2–Probable peak flow and discharge unit relationship for office buildings

TABLE II – LOADING WEIGHTS (DISCHARGE UNITS) FOR VARIOUS SANITARY APPLIANCES

Appliances	Use time t (seconds)	Interval between uses, T seconds)	Probability of use P	Flow rate, lit/sec.	Loading weights (discharge units)	Assumed failure rate
Hunter (1)–Public Use						
Bath	120	1800	0.067	0.61	3	0.01
W. C.	60	300	0.20	0.30	5	
Griffiths (2)–Public Use						
Urinal (per stall)	15	1200	0.0125	0.30	1	
Basin	10	600	0.0167	0.60	1	0.01
W. C. 2 gal.	5	600	0.0083	2.25	7	
W. C. 3 gal.	7	600	0.0117	2.25	10	
CBRI–Office Building						
Urinal (per stall)	10	600	0.0167	0.45	1	
Basin	—	—	0.184 (average hourly)	0.50	3	0.01
W. C. (12.5 lit.)	12	831.4	0.0144	1.83	6	

Probabilities of use of different sanitary appliances, their flow rates and the loading weights (discharge units) assigned in this study for a chosen standard of service has been presented in Table–II along with the findings of other researchers.

Marked difference in probability of use of wash basin and that of w.c., as observed in the present study, justifies the effect of climatic conditions and user's habits over the frequency of use in tropical countries like India.

Conclusions

The study was conducted on a relatively few toilets taken at random in three office buildings under Indian Conditions of use during peak summer months. Although present study does not provide data for use pattern of sanitary appliances during other seasons of the year, the investigation furnishes sufficient data for designing the stack based on probable peak flow out of total number of appliances installed in a office building for critical months of the year. However, further research is warranted for a wider range of data on probabilities of use use and to improve upon the relationship between probable peak flow and discharge units.

Acknowledgement

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References

1. Hunter, R. B., 'Methods of estimating loads in plumbing systems', U. S. National Bureau of Standards, Building Materials and Structures Report BMS 65 (1940).

2. Griffiths, T. J., 'The hydraulic design of drainage pipe work for domestic and for public buidings', The Public Works and Municipal Services Congress in Conjunction with B. R. S. (U. K.), (1962).