Proposed Drainage Tunnel Schemes for Flood Protection

Comments by

Joseph Hun-wei Lee
Redmond Professor of Civil Engineering
The University of Hong Kong

Honorable LegCo Panel members, Ladies and Gentlemen:
I would like to share with you some comments on the proposed drainage tunnel schemes for flood control. These views are based mainly on the briefing document and my reading of related published articles, and my local and international experience as a hydraulics researcher and expert advisor over the past 20 years. Since 1987 I have taken an interest in flooding problems in Hong Kong, and have conducted applied research in connection with a number of drainage or flooding projects: e.g. the River Indus in Northern New Territories, the Yuen Long Bypass Floodway, and the Tai Hang Tung Storage Scheme.

1. **Urban Flooding and Global Climate Change**:
   Whether flooding occurs in a region depends on i) the rainfall input on the watershed, ii) the nature and relief of the land terrain, and iii) the downstream sea level. There is nothing we can do about the third factor - past flooding events often occurred in High Tide, a purely chance event. Let us turn to the first two factors.

   In recent years urban flooding has become an important topic globally; one only needs to see the level of interest in international conferences on these topics (such as urban stormwater drainage or flood defense). In the past decade both the frequency and intensity of flooding seem to be increasing. Devastating floods have claimed thousands of lives and caused economic loss of billions dollars: e.g. the Mississipii River flood in 1993, the Rhine River flood in 1995, the Yangtze River flood in 1998, the Haihe River flood in 1996. Global climate change seems to have its impact on extreme hydrological events. Worldwide we have seen an increase in the concentration of Greenhouse gases such as carbon dioxide (largely the product of fossil fuel burning, from about 270 ppm to 365 ppm in 1998). We have seen steady increases in global temperature over the last 100 years and have experienced frequent extreme warm years in the recent past. Sea level has been rising. The insurance business has been facing increasing claims due to natural disasters like floods and hurricanes/typhoons. The predictions are that global mean temperature in the 2036-2046 decade will be 1-2.5 K warmer than pre-industrial times, with 90 percent confidence.

The Rainfall Input

In Hong Kong we also have seen some climate change in recent years. In the last decade (the 1990s), we witnessed several very warm years. For example, 1998 was the warmest year since records began in 1884, with an annual mean air temperature of 24 degrees Celsius. 1997 was the fourth warmest year, with an average temperature of 23.4 degree Celsius. The unusally warm weather seems to be correlated with the record high rainfall inputs in recent years.

The long term average annual rainfall in Hong Kong is 2,200 mm. About 80 percent of the rain falls between May and September. The wettest month is August, with an average monthly rainfall of 391 mm.

And yet in 1997 we had the highest annual rainfall of 3,343 mm (the wettest year); we have seen extensive flooding in the Mongkok area. Last year, 2001, was the fourth wettest year, with annual rainfall of 3,091 mm - June 2001 was the wettest month of June in the hundred years record of the Hong Kong Observatory; 1,368 mm of rain fell on the Northern NT in that month alone, i.e. 62 percent of the mean annual rainfall. This has led to wide spread flooding in the NT and Tsuen Wan. Even if one accepts the uncertainty of extreme hydrological events, one has to conclude that the climate change at least partly explains the observed frequency of floods. It is sometimes perplexing to the public why we have seen increasing floods of a magnitude exceeding that of a ten year recurrence interval - when in theory this should occur only once every ten years, on the average. This seems to be related partly to the changing climate, and partly to the spatial variability of the rainfall.

Land Terrain and Relief

It is a fact that urbanisation and change of land use have led to more severe urban floods. Typically stormwater drainage systems are designed for peak flows. The peak flow expected at the outlet of a catchment depends very much on the nature of the land surface. In general urban development is associated with an increase in the proportion of paved area; this in turn increases the peak runoff. For example, the change of a land surface from grassland to concrete in a catchment can change the 'runoff coefficient' from 0.25 to nearly 1.0, increasing the peak runoff by a factor of four. This implies a significant increase in the drainage capacity required. The change in land use (e.g. areas taken out of its temporary flood storage or detention purpose) also results in increase of peak stormflow and sometimes reduction of drainage capacity (effect of reclamation).

Honorable Panel Members, the point of all these figures is that flooding has undoubtedly become more severe in Hong Kong, and that necessary measures must be adopted to safeguard property and lives.

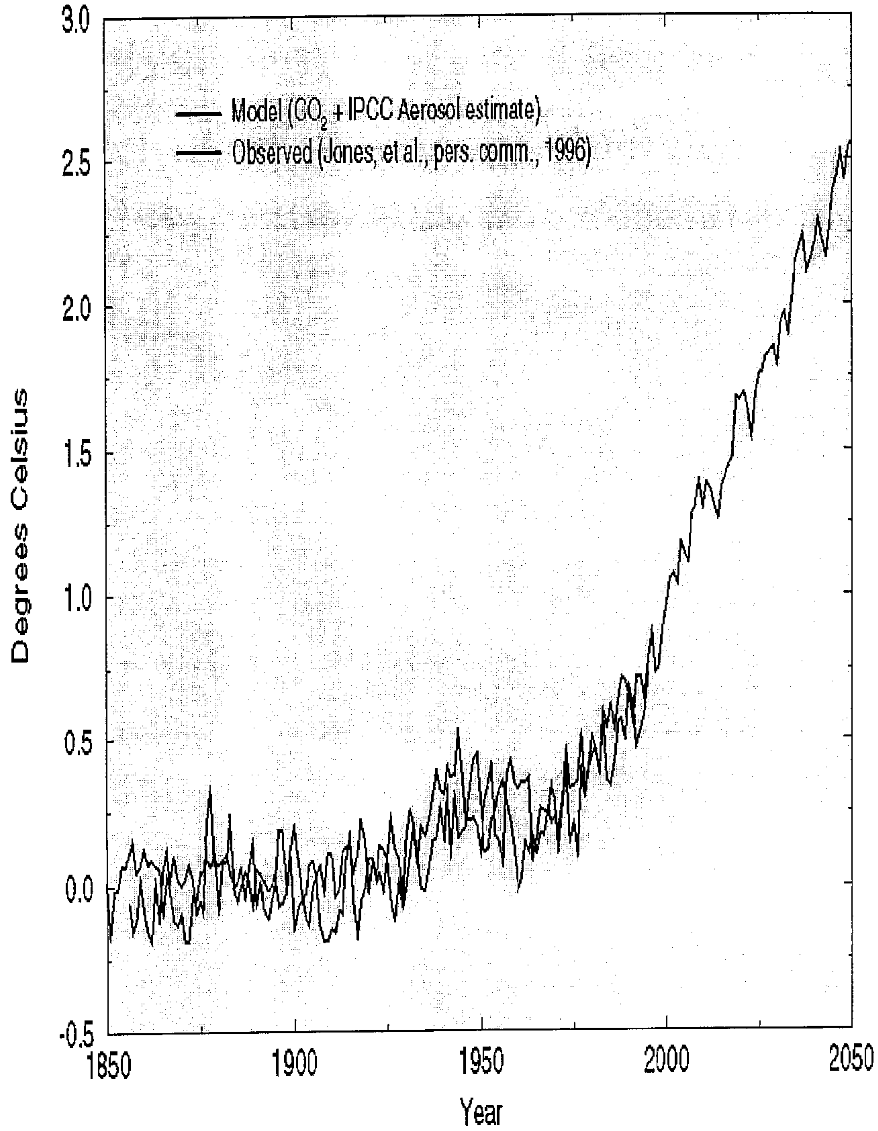
2. **The Proposed Drainage Tunnels**

Given the need for flood protection, the question is whether the scheme is technically sound. In Hong Kong the upstream terrain is usually steep followed by a much gentler gradient in the downstream urban areas. I generally accept the conclusion from mathematical models that flood protection to the required standard will not be met if the required drainage improvement measures are not undertaken. The drainage analysis is based on state-of-the-art industry standard models, and the conclusions are consistent with the driving forces. I generally concur with the view that it is more cost effective to go for upstream diversion or storage schemes for flood protection downstream in order to overcome the problems with traditional sewer widening schemes: i) traffic and business disruption; ii) air and noise pollution; iii) difficulties due to interfering underground utilities and sewers, water supply pipes. The details of the benefit-cost analysis would depend on the particular scenario and on the assumptions used, but the general principle is valid. The provision of the drainage tunnels for Hong Kong Island, Lai Chi Kok/West Kowloon, and Tsuen Wan would seem to me a sensible integration of concepts of upstream diversion and existing proven technology in tunnel construction. After all, our existing water supply system consists of an elaborate reception and transfer system, with some 37 km of catchwater channels and tunnels built to intercept water. For example, tunnnels are used to convey water from Tai Lam Chung Reservoir to the Tsuen Wan Treatment Works, and from the High Island Reservoir to the Shatin Treatment Works. The proposed gravity-driven drainage tunnel system makes use of the water head available in the steep terrain, and there is no need for pumping. It appears to be a promising robust system. While there are technical issues that need to be finalized by further study (e.g. design of the final stormwater outlet in tight space; use of pressurized but smaller tunnels), the scheme appears to be hydraulically sound. Through a combination of mathematical and physical model studies these drainage tunnels can be designed. For example, the photo shows a view of a laboratory model of the underground Kai Tak Transfer Tunnel which diverts stormwater flow from the underground Waterloo Road stormwater culvert, and runs beneath the Kowloon Tong and Kowloon City area into Kai Tak Nullah. This is a 4 m diameter tunnel designed to divert 40 cumec or 2/3 of the upstream stormwater flow that would have drained into the Mongkok black flooding spots.

An additional comment: as these are large tunnels they also have the potential of some storage of water. I wonder if the feasibility of using the rainwater for some types of non-drinking water supply have been looked into (e.g. for firefighting, wetlands, cooling water, irrigation, toilet flushing). Right now the East River supplies over 70 percent of our demand for water. This diversion of the East River to supply water to Hong Kong also affects the water flow and quality in the remaining parts of the East River system and the Pearl River Delta. In the future, as Guangdong Province continues to develop economically, the long term sustainability of this water supply will probably need to be re-examined in a broader environmental context. And in Hong Kong, any measures to make use of the precious rain water would be welcome.

Global Mean Surface Air Temperature

(Departure from 1880-1920 base period.)



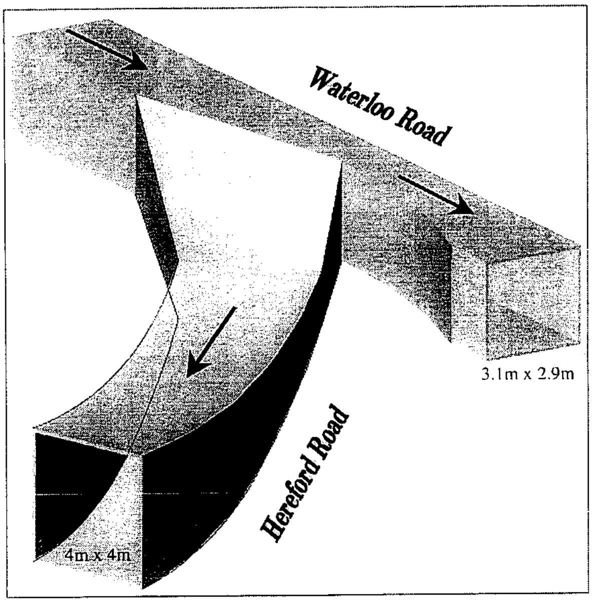


Fig.2.3.4: Perspective view of KTTS interception structure

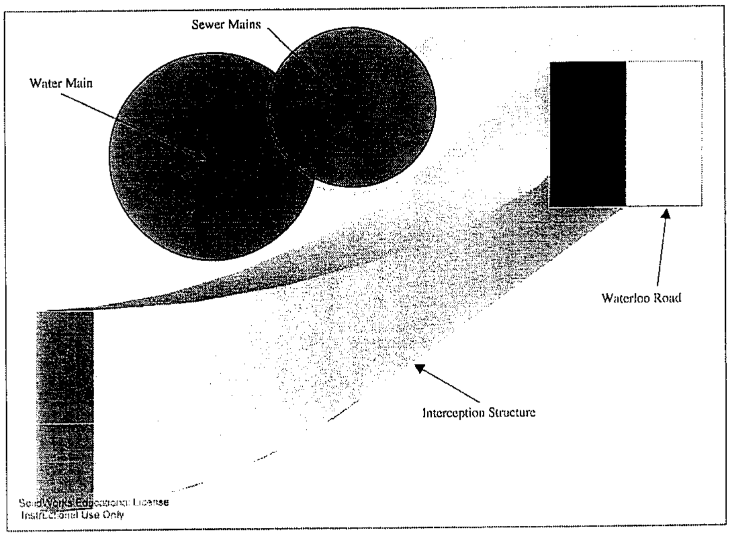


Fig.2.3.5: Location of water and sewer mains

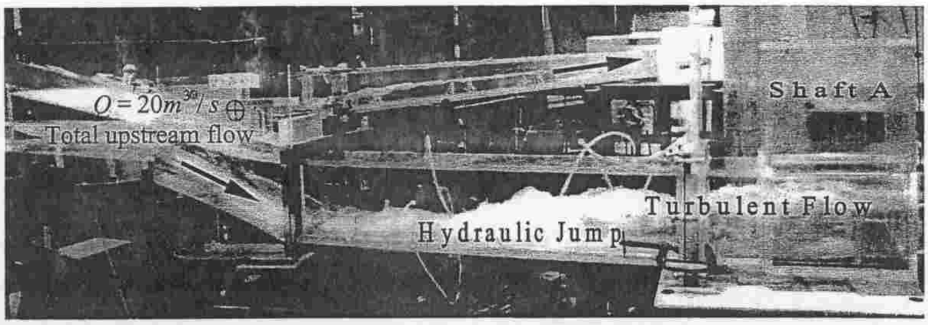


Fig.4.1.3: Observed spillway flow and subsequent jump in interception structure

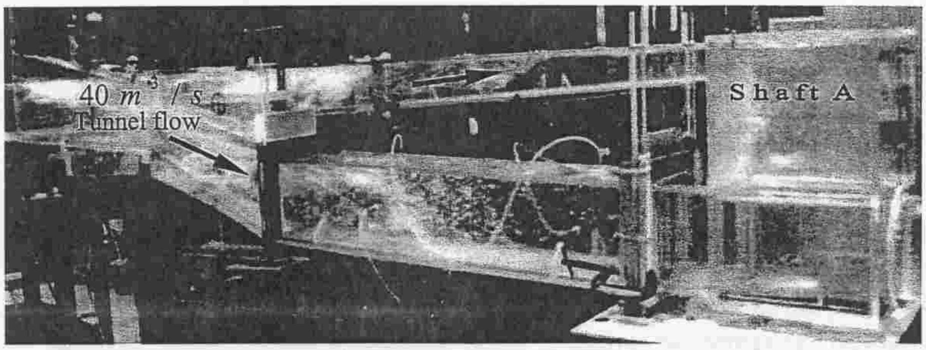


Fig.4.1.4: Observed flow when Shaft A is at the brink of surcharge