Theme: Disaster Response

Fires Following Earthquakes: an innovative approach by the City of Berkeley, CA (USA)

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Background

Historically, the major secondary effect of earthquakes has been fire. The San Francisco earthquake of 1906, the Tokyo earthquake of 1923 and the Kobe earthquake of 1995 are renowned as much for their fire damage as for their earthquake effects. The conflagration fires from these earthquakes were mostly due to wind and high density wood construction.

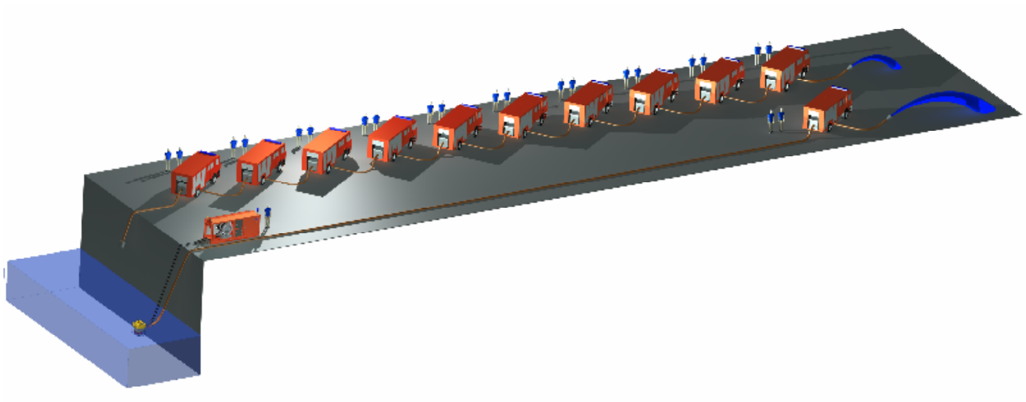
In addition to the high risk of fire following earthquakes, public water supply systems, particularly in areas of poor soil conditions, have typically performed poorly during earthquakes, resulting in dropping pressure in water supply mains or even loss of water supply for fire protection. The 1989 Loma Prieta earthquake demonstrated it to the City of Berkeley. See photo below.

Problematic

Despite widespread efforts in the Bay of San Francisco basin over the last several decades to upgrade water supply systems, it is expected that water supply will be severely impacted by a large earthquake due to pipe breaks and tank failures.

Fire departments in many areas will have to resort to alternative open-water sources. However they will be handicapped in this since fire trucks need to carry hard suction hose for that task. Then relay pumping mobilizes a large amount of resources (fire trucks & personnel) as a truck is needed approximately every 200-250m to pump water over large distances.

A number of opportunities exist for mitigating this problem, including construction of a seismically reliable saltwater pumping system. Alternative water supply capability needs to be enhanced. Hard suction hoses should be carried on all fire trucks to access open-water sources. Above-ground large diameter hose systems should be implemented to avoid having to rely on relay pumping.



This picture illustrates the difference between traditional relay pumping using fire trucks and their crews and the use of a modern above-ground mobile super water supply system (also known as High Volume Pumps or HVP).

Following an earthquake event, the problem will always be the water supply, in terms of access, time & distance as well as manpower required.

To respond to such a shortfall, following the 1989 Loma Prieta earthquake, in 1992, the City of Berkeley considered, under Measure G, the idea of a new fixed underground saltwater pump and pipe system.

The Measure G project included information about the predicted number of fires that might occur after a magnitude 7 earthquake on the Hayward Fault and how much water might be required to control those fires. Whilst it wasn't expected that all zones of the existing East Bay Municipal Utility District (EBMUD) water system will fail at once, there is a real possibility of some zones not having water or reduced flow, thus hampering fire fighting activities. It is interesting to note that the maximum projected number of fires was 26 fires with a fire water flow demand of 288,000 litres per minute.

Eventually the idea of a new fixed underground saltwater pump and pipe system was found not to meet fire fighting needs in terms of coverage. Furthermore it was not affordable and was opposed by communities that would be impacted by the construction.

The basic reason the idea of a hard pipe underground supply system was abandoned is that, in 1998, the $30 million of bond money ear-marked for the project could only buy a water system pipe layout a third of what had been envisioned in 1994 and therefore provided minimal coverage of the city. See below.

Planned water system pipe layout

1994 (original)

1998 (revised)

The original layout envisioned in 1994 was to have two pump stations near the bay front that could move salt water in amounts of 75,000 L/min to cover roughly 6 square miles of Berkeley from the bay to the 60m elevation. This was to be a looped, hence redundant, water system supplying three main corridors from the bay to the foot of the hills (West to East) and being interconnected at the bay and the 60m elevation (North to South) covering the main industrial and commercial areas of Berkeley. Included in the area is a majority of the housing for Berkeley. The hill area of Berkeley while containing a major university (UC Berkeley) and research facility (Lawrence Berkeley National Lab) and about 10,000 residences was not directly covered by the system but would still have benefitted to some degree from the system.

When all the engineering had been done, the system presented in 1998 included a single pump station and single line of pipe through the center of the city (hence no redundancy) delivering the same amount of water (75,000 L/min) at the 60m elevation. However there was serious doubt about the $30 million being enough to actually build the system. In addition the single pipe line provided minimal coverage of the city and the fire department's equipment at the time could branch off for a distance of maybe 600m from the line. Therefore coverage was about 1 square mile.

An additional problem that has developed since the inception of this project is the reduction in the EBMUD water system capacity, which was done to maintain water quality. The need to maintain water quality and preservation of supply are in conflict with the flow needed to suppress fires.

Solution

Measure G did not allow for purchase of mobile equipment but only for capital facilities (e.g. seismic retrofit and construction of public safety facilities, police, fire and emergency operations).

In 2000, the voters approved Measure Q, thus providing funding for a Mobile Disaster Fire Protection System (MDFPS) in lieu of the 1992 Measure G considered for a new fixed underground saltwater pump and hard pipe system.

The need for a MDFPS is based on the predicted failure in areas of the existing EBMUD system that provides water for fire fighting after a major earthquake.

In 2002, the original Request For Proposal (RFP) for the mobile water system was issued and included: pumps, hose, delivery & recovery of hose, connections and vehicles. A revised RFP was issued in 2005.

The proposals were evaluated at three levels:

- by the City of Berkeley Fire Department,
- by a team of representatives from the Fire, Police and Public Works Departments of the City and an experienced seismic engineer and
- by an outside engineering firm that did a peer review of the City review process.

The performance criteria of the MDFPS used were as follows:

- operational safety and regulatory compliance
- deployment efficiency and range of use
- operation characteristics
- flow capacity and discharge pressure (for pumps)
- marketplace history and existing unit reliability
- total cost

On May 8, 2007 the City of Berkeley Council approved spending of $4.7million in bonds to implement its mitigation project and acquire its MDFPS from Dutch company HYTRANS.

Providing coverage even to the hill area of Berkeley, the MDFPS actually provides coverage to a greater area of the city than the one envisioned in 1994.

The City of Berkeley is of course aware that a system like its MDFPS can be of greater use, not only for fires following earthquakes, but also for peri-urban bushfires, flood response and even large industrial fires.

How does the MDPFS system work?

… or how does this water move 9 kilometres away and 150 metres uphill from the San Francisco Bay?

After considering alternatives, the city focused on a rapidly deployable, mobile system of floating hydraulically-driven pumps and long lengths of flexible lay-flat large diameter hose (LDH) thus drastically reducing loss to friction.

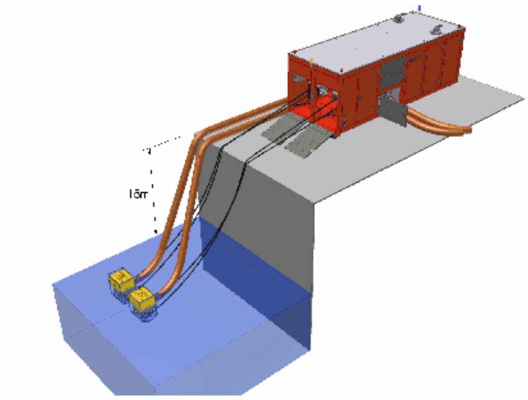
The City of Berkeley's MDFPS uses Large Diameter Hoses and High Volume Pumps. This technology provides a less expensive and more mobile system with better coverage to the entire city, is scalable for various situations, and provides more fire fighting options. This system can pump saltwater from any of the available sources such as ocean, bay or Aquatic Park, in addition to other fresh water sources like lakes and reservoirs.

The City of Berkeley has established that a standard deployment team is five personnel. Using two trucks a team will pick and deploy a pump using 3 people to set it up and then operate it. In the meantime, two of the pump setup group will start deploying hose and deliver traffic control devices along the planned route.

A diesel engine power pack drives the submersible hydraulic pump, which pushes water through the hose. Using a submersible pump eliminates the height limitation and capacity losses traditionally associated with the drafting operation, i.e. when sucking water up a hard-suction hose.

Furthermore the submersible pump is linked to its powerpack by means of 60m long hydraulic hoses allowing access to any open-water sources within 60m from the powerpack. There is no more need to have heavy equipment stand very close to the water.

Another innovation comes from the ability to use, rapidly deploy and recover LDH, which, at 5kg per linear meter, with 25kg coupling, are to heavy and bulky to be man-handled. Deploying the hose is as simple as letting it drop at 35km/h from the back of a truck. The recovery has been mechanized. The Hose Recovery Unit is capable of recovering 1km of LDH with only three persons in 45min. No hoses have to be uncoupled and no heavy manual lifting is required anymore.



Illustrations of the HydroSub900 unit with its 2 submersible pumps and powerpack and of the Hose Recovery Unit in action.

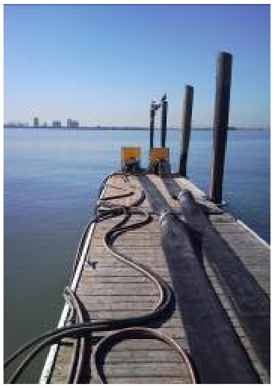
Discussion

The September 4 2010 Christchurch earthquake has demonstrated once again that utility services will be greatly impacted by a Magnitude 7+ earthquake.
Fortunately, whilst the New Zealand Fire Service (NZFS) received more than 4000 calls for assistance, they didn’t record many fires. They intervened on a lot of small ones and a couple of big ones but there was no conflagration. NZFS estimates that this is because there is little street gas in Christchurch. Dwellings mostly use portable gas cylinders.
As a consequence the September 4 Christchurch earthquake didn't tax the fire service in terms of water.

Whilst Australia sits in the middle of the Australian tectonic plate making its capital cities less earthquake-prone than neighbouring New Zealand’s; our country is not immune as the 1989 Newcastle earthquake reminds us.

Considering that the standard response tool of Australian Fire Agencies is the fire truck and that beyond the pump on-board those trucks, no enhanced pumping capability exists in the country, it may be worthwhile acquiring a national enhanced pumping capability like the City of Berkeley’s.

On October 21st 2010, the City of Berkeley will organize an official launch and demonstration to the media of its new enhanced pumping capability, the Mobile Disaster Fire Protection System, a system articulated around several HYTRANS HydroSub900 mobile High Volume Pumps (22,000L/min at 12bar) and approximately 10km of 12" Large Diameter Hose with Hose Laying Container, Hose Recovery Units, Hose Ramps, etc…



Illustrations of the City of Berkeley's HydroSub900 powerpack, a hose container truck and a jetty with 2 submersible pumps ready for deployment

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Acknowledgements

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