International Journal of Civil and Structural Engineering– IJCSE
Volume 3 : Issue 1 [ISSN : 2372-3971]

Publication Date: 18 April, 2016

EXPERIMENTAL INVESTIGATION OF THE HYDROGRAPH CHARACTERISTICS EFFECT ON THE FLOOD PROPAGATION DUE TO THE FAILURE OF THE DISTORTED PHYSICAL MODEL OF ÜRKMEZ DAM

M. Şükrü Güney, Gökmen Tayfur, Tanıl Arkış

***Abstract*- Effect of the hydrograph characteristics on the flood propagation due to dam break is studied by means of a distorted physical model of Ürkmez Dam, built in the scope of the TÜBİTAK 110M240 project, in open area of Hydraulics Laboratory of Dokuz Eylül University. The physical model has a horizontal scale of 1/150 and a vertical scale of 1/30 and it contains the reservoir and the downstream part of the dam until the sea. The Ürkmez dam was chosen since it has reasonable dimensions and it's located close to Ürkmez village. The dam break was simulated by lifting the trapezoidal or triangular parts of the dam body to reflect the partial dam break, and also by lifting the gate suddenly in order to reflect the sudden failure. The water depths were measured by using e+ WATER L (level) sensors. The velocities were determined by Ultrasonic Velocity Profiler (UVP) transducers. The propagation of the flood wave was recorded by a HD camera. In this paper, the design and construction of the distorted physical model and the measurement method are outlined. Some experimental findings corresponding to different hydrographs are presented and compared.**

***Keywords*—physical model, distorted model, dam break, flood propagation**

I. Design of the Distorted Model

The distorted physical model of the dam with its reservoir and downstream part was designed to investigate two dimensional flood wave propagation as a result of a dam failure, in the scope of the Project TUBITAK 110M240. Some experimental and numerical results related to the partial break without vegetation were presented previously (Guney et al., 2014; Guney et al., 2015). Ürkmez Dam was selected because

M. Şükrü Güney
Dokuz Eylül University,
Turkey,

Gökmen Tayfur
Izmir Institute of Technology,
Turkey,

Tanıl Arkış
Dokuz Eylül University,
Turkey,

Fig. 1. The general view of the studied area (maps.google.com)

of settlements on its downstream part. The general view of the studied area is given in Fig. 1. The physical model was designed according to the Froude similarity law since the gravitational force is dominant. The horizontal and vertical scales of the model were selected so that it can be built and operated conveniently and still be big enough to measure flow depths and velocities with sufficient accuracy. According to the available space in the open area of the Hydraulics Laboratory within Dokuz Eylül University, the horizontal and vertical scales were selected as $\ell_{xr} = 1/150$ and $\ell_{zr} = 1/30$, respectively. Thus, the distortion coefficient is $n = \ell_{zr}/\ell_{xr} = 5$ and the following scales may be defined (Yalin, 1971):

The slope scale:

$$S_r = \ell_{zr}/\ell_{xr} = n \quad (1)$$

Fig. 2. The initial sight of the construction area.

The cross-sectional area scale:

$$A_r = \ell_{xr}\,\ell_{zr} \qquad (2)$$

The volume scale:

$$V_r = \ell_{xr}^{\,2}\,\ell_{zr} \qquad (3)$$

The geometric characteristics of Ürkmez Dam (prototype) and its distorted physical model are given in Table 1.

TABLE I. THE GEOMETRIC CHARACTERISTICS OF THE PROTOTYPE AND PHYSICAL MODEL

Characteristics	***Prototype***	***Physical model***
Crest length (m)	426	2.84
Crest width (m)	12	0.08
Dam height from its base (m)	32	1.07
Lake volume at minimum water level (m3)	375 000	0.556
Lake volume at maximum water level (m3)	8 625 000	12.778
Lake volume at normal water level (m3)	7 950 000	11.778
Lake active volume (m3)	7 575 000	11.222

The Froude number is formed by a typical velocity which is in the x direction of the flow. Therefore, the Froude velocity scale is interpreted as

$$v_r = v_{xr} = \sqrt{\ell_{zr}} = 1/5{,}48 \qquad (4)$$

which gives for the time scale of the distorted model:

$$t_r = \frac{\ell_{xr}}{\sqrt{\ell_{zr}}} = \frac{1}{n}\sqrt{\ell_{zr}} = 1/27{,}4 \qquad (5)$$

A. *Construction of the Physical Model*

The sight of the area of about 300 m2 which was reserved to the construction of the physical model is given in Fig. 2.

Fig. 3. Placement of the fill material in the lake

Fig. 4. Formation of the concrete surfaces

This area was arranged and concrete was poured after the placement of the reinforcing bars. The cross-sections concerning the dam lake were drawn by using the related maps. The sections were manufactured from metal.

After placement of the cross sections and construction of the lake walls, the lake region was filled with granular material (Fig. 3).

The downstream region was constructed in a similar manner and the surface was lined with concrete (Fig. 4).

The final shape of the dam lake is given in Fig. 5.

The houses and the main highway connecting Seferihisar to Kuşadası were also constructed in compliance with related maps and documents.

The completed downstream part of the model is shown in Fig. 6.

Fig. 5. Final shape of the dam lake

Fig 6. The completed downstream part of the physical model

II. Measurement Method

The flow depths were measured by e+ WATER L level sensors (Fig. 7). These level sensors were distributed over the lake and downstream part of the Ürkmez dam. The level measurement values are automatically compensated for variations in air pressure and water density variations due to temperature fluctuations. The velocities were measured by means of UVP (ultrasonic velocity profiler) and its transducers (Fig. 8). Fig. 9 shows locations of the level meters (S1, S2…, S11) and UVP transducers (U1,U2,…,U5)

Fig. 7. e+ WATER L level sensors

Fig. 8. UVP transducers

III. Experimental Findings

A. *Flood hydrographs*

The partial dam break was simulated by lifting the trapezoid or triangular shaped part of the dam body. The sudden collapse of the dam body was realized by lifting the gate (Fig. 10).

The water levels with respect to time in the lake were registered by means of the level meter S1. The so measured values are converted to the volume by using the previously determined volume-water depth curve of the model reservoir. Time dependent water depth values allowed the determination of the discharge values of the hydrograph. The hydrographs determined in this manner are given in Fig. 11.

Fig. 9. Locations of the level meters (S1 S2, …, S11) and UVP transducers (U1,U2, …, U5.)

International Journal of Civil and Structural Engineering– IJCSE
Volume 3 : Issue 1 [ISSN : 2372-3971]

Publication Date: 18 April, 2016

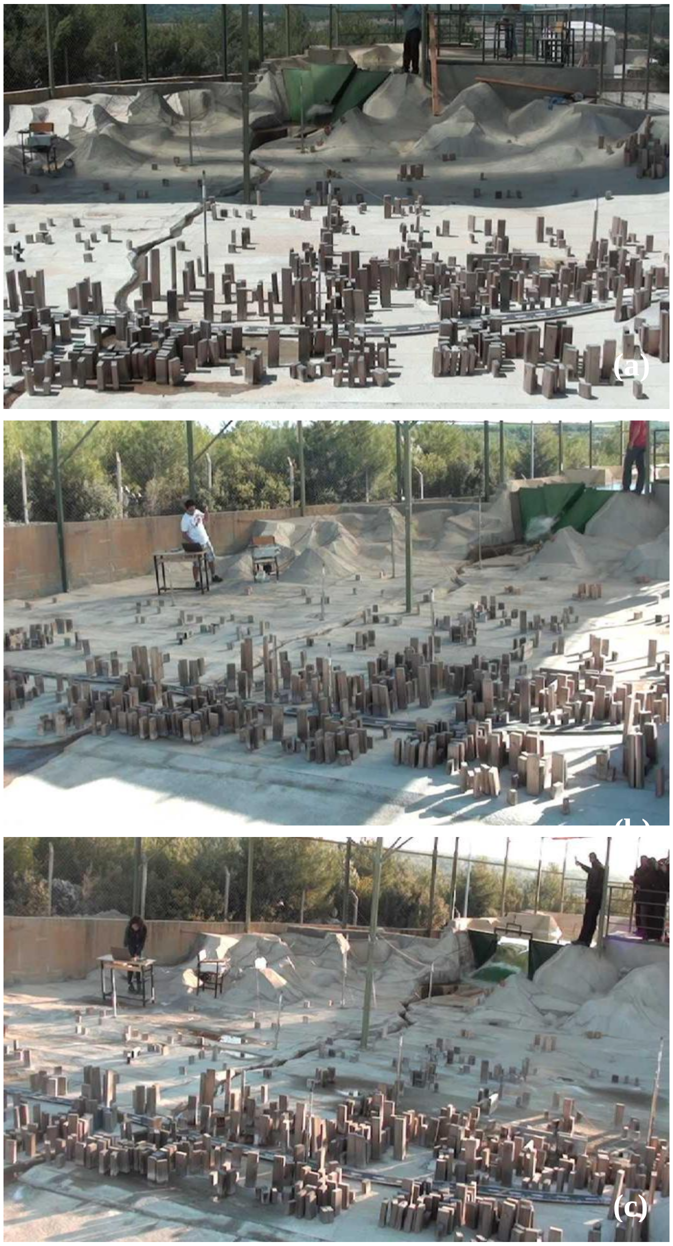


Fig. 10. The beginning of the experiment for (a) trapezoidal (b) triangular and (c) sudden collapse scenarios

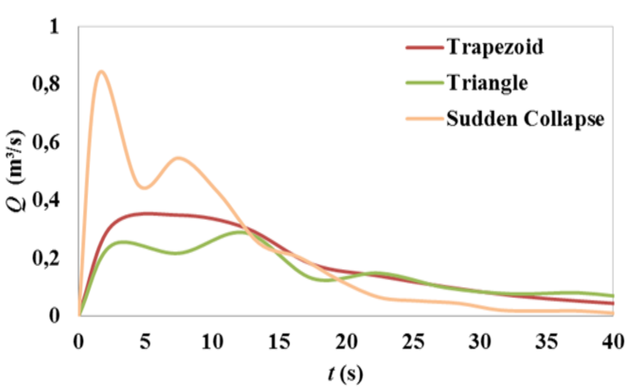
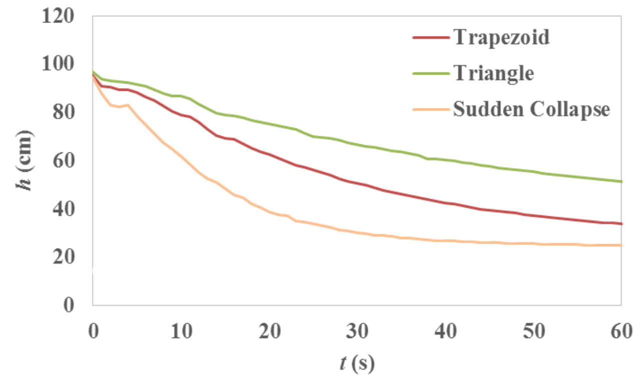


Fig. 11. Hydrographs corresponding to different types of collapse (trapezoidal breach, triangular breach and sudden collapse)

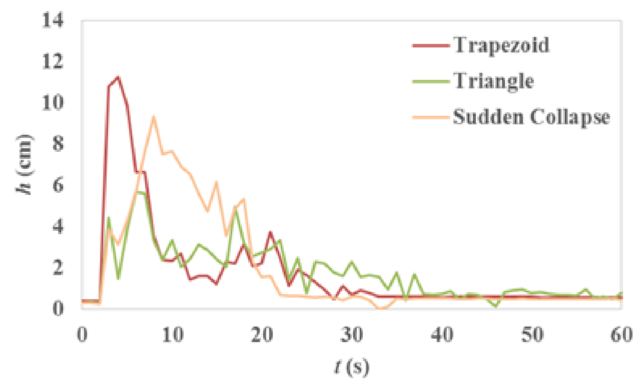
B. Variations of water depth and velocity with time at certain points

Time varied water depths at different locations are given in Fig. 12.

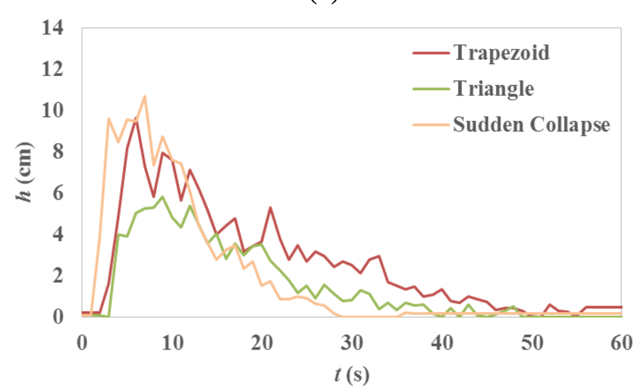
Time varied average velocity values are given in Fig. 13.



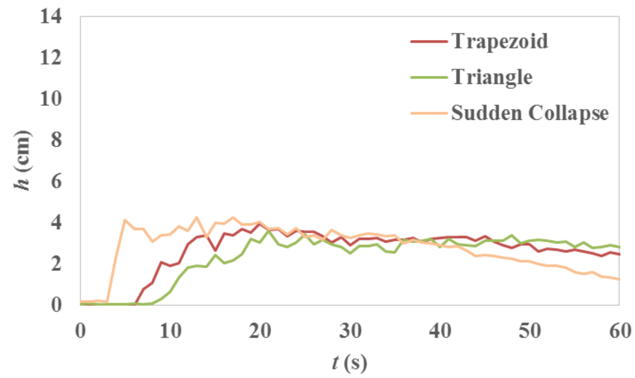
(a)



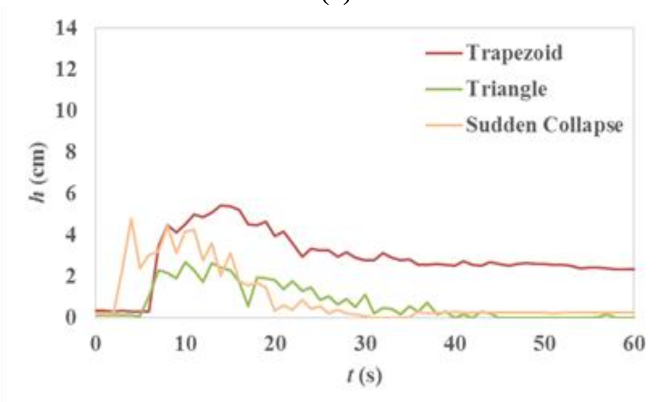
(b)



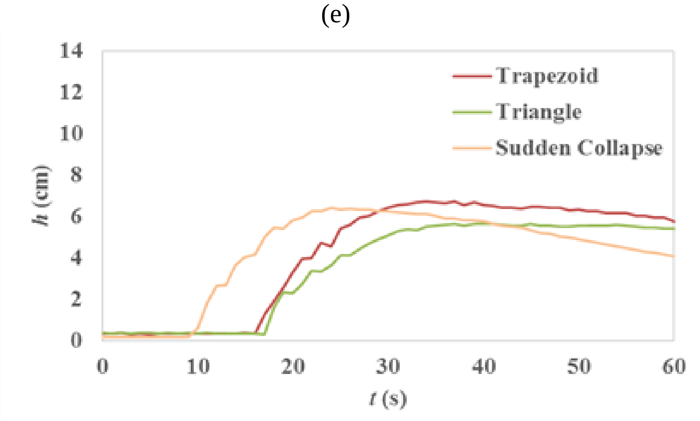
(c)



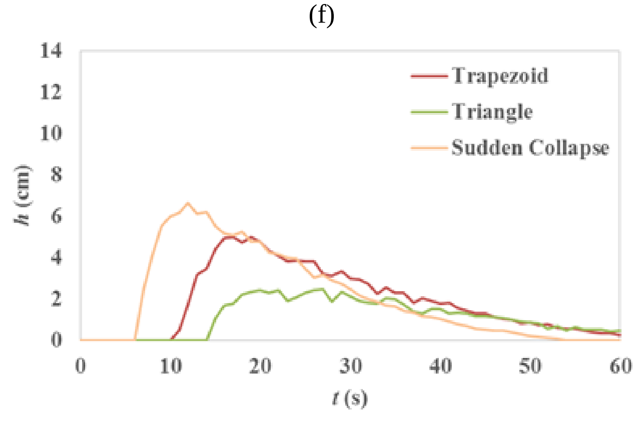
(d)



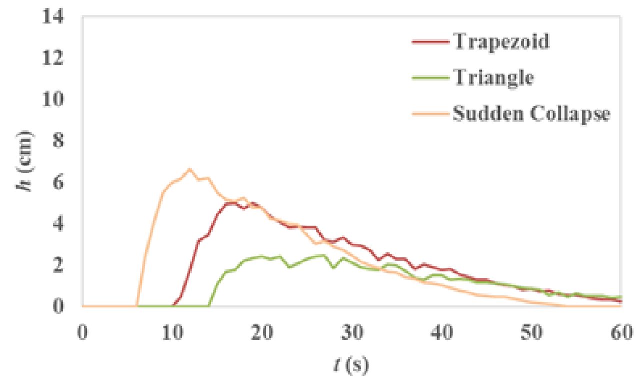
(e)



(f)



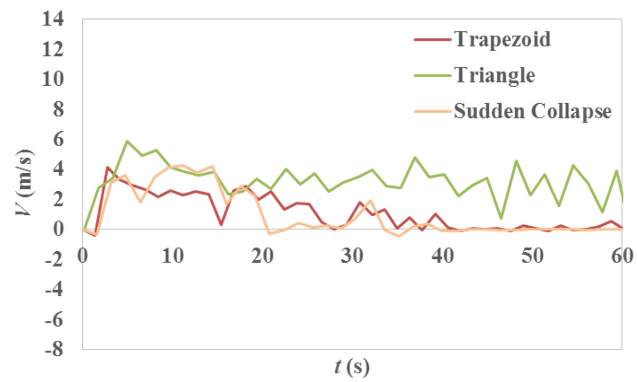
(g)



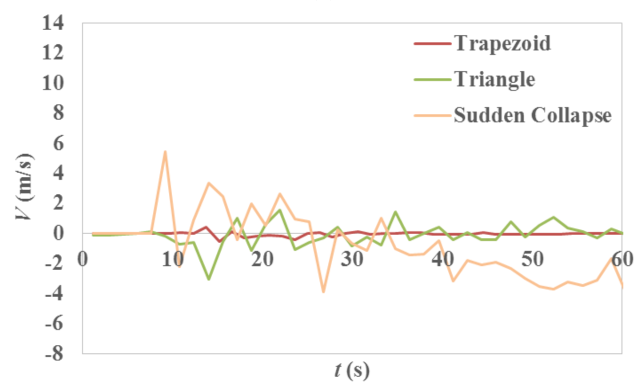
(h)

Fig. 12. Water depths measured at different locations (a) S1, (b) S3, (c) S4, (d) S5, (e) S6, (f) S7, (g) S10 and (h) S11

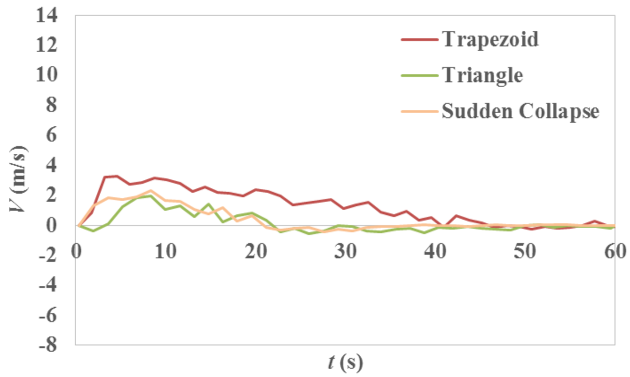
Time varied average velocity values are given in Fig. 13.



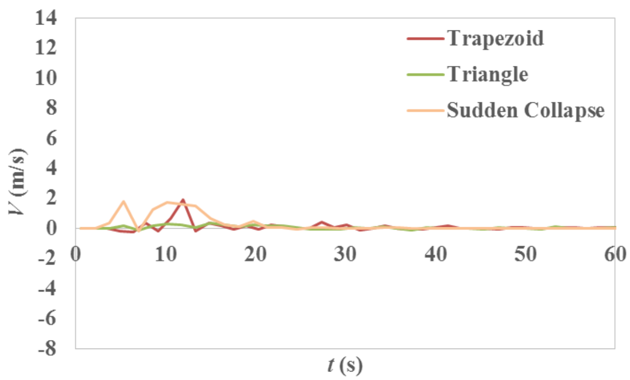
(a)



(b)



(c)



(d)

Fig. 13. Depth averaged velocities at different locations (a) U1, (b) U5 (c) U2, and (d) U4

C. *Flood Propagation*

The propagation of the flood was recorded by a HD camera. The regions reached by the flood wave at 2 s, 8 s, and 16 s are given in Fig. 14, Fig 15, and Fig 16, respectively.

a) trapezoidal breach,

b) triangular breach

c) sudden collapse

Fig. 14. The regions to which the flood wave reached at time 2 s. a) trapezoidal breach, b) triangular breach, c) sudden collapse

a) trapezoidal breach,

b) triangular breach,

c) sudden collapse

Fig.15. The regions to which the flood wave reached at time 8 s. a) trapezoidal breach, b) triangular breach, c) sudden collapse

a) trapezoidal breach,

b) triangular breach,

c) sudden collapse

Fig. 16. The regions to which the flood wave reached at time 16 s.

IV. Conclusion

A distorted physical model of Ürkmez Dam was designed and built in order to study the flood propagation due to dam break resulting from trapezoid, triangle shaped breaches and also sudden collapse. The water depths and velocities were measured by means of elaborated devices.

In the sudden collapse case the flood wave reached earlier the measurement points. In the sudden collapse case, the flood wave reached the sea about in 6.1 s. which corresponds 2.8 minutes in the real life. The maximum water depths measured in the sudden collapse case was 11 cm (corresponding to 3.3 m in the prototype) which may cause serious damages in certain regions of Ürkmez village. In the triangular breach case, the highest velocity measured was about 6 m/s (which implies 32.88 m/s in the nature) and such a velocity is capable to create serious damages in terms of life and property. The left coast was effected more from the flood wave in the case of the trapezoidal breach compared to triangular breach and sudden collapse cases.

The experimental findings continue to be analyzed and interpreted in the light of existing literature knowledge. Numerical study also continues to be performed by using the software FLOW3D.

Acknowledgment

This study was financially supported by TÜBİTAK through the 110M240 project. Our gratitude goes to the İzmir Department of DSİ, İzmir Municipality and İZSU Administration for their contributions on the acquisition of the required drawings and the relevant maps. The writers would also like to thank Prof. Dr. Turhan ACATAY for his valuable advises.

References

[1] M.Ş. Güney, G. Tayfur, G. Bombar and Ş. Elçi, "A distorted physical model to study sudden partial dam break flows in an urban area" , Journal of Hydraulic Engineering, 2014.

[2] M.Ş. Güney, G. Tayfur, T. Arkış., G.Bombar, "Experimental and numerical investigation of flood propagation due to trapezoidal breach in the distorted physical model of Ürkmez dam", Dam Engineering, Vol XXV,issue 4, pp. 171- 187, 2015.

[3] M.S. Yalın, Theory of Hydraulic Models, The Macmillan Press Ltd, London, 1971.

[4] http://maps.google.com

[5] http://en.eijkelkamp.com/products/water/hydrological-research/water-level-measurements

[6] http://www.met-flow.com

[Experimental results will also be compared with Flow3D numerical solution. Sudden collapse case is the most demolisher one.] Tanıl Arkış