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Hazard and Total Risk Analyses of Large Dams under Threat of the North Anatolian Fault Zone in Mid-Anatolia, Turkey

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***Abstract* -** Large dams built on the seismically active area have a high-risk potential for downstream life and property. Active faults, which are located close to dam sites, can induce to damaging deformation of the embankment as well as on instability of the embankment and strength loss of foundation materials. Case studies about the seismic performance of dams under major earthquakes are available in the literature. There are so many dams, which are under the threat of near energy sources in Turkey. Most of them has been located in the Northern part of Mid-Anatolia, Turkey. These are Almus, Atakoy, Boztepe, Camlıgöze, Degirmendere, Golova, Kılıçkaya, Koyulhisar, Sureyyabey, Tepekisla, Ulukoy, Vezirkopru, Yassical, Yedikir, and Ziyaret dams having a structural height between 20 and 134 m. These dams are very close to the North Anatolian Fault, which is famous structural feature that produces deathful earthquake. In otherword, these dams are located on or near active faults (less than 10 km). It means that all of them are under near-field motion. The total risk analyses depending on the seismic hazard rating of dam site and risk rating of the structure have concluded that most of them, which are under near source effect of the North Anatolian Fault Zone, generally have high-risk class. The author thinks the fact that these dams must be analyzed with high priority and redesigned to increase the safety of the embankments and their appurtenant structures, if necessary.

***Keywords*:** Earthquake, dam, Safety evaluation, Seismic hazard, Total risk,

1. Introduction

Safety evaluation for large dams, which are under near source effect, is an important aspect in dam engineering. Case studies about the seismic performance of dams under major earthquakes are available in the literature. The earthquakes can result damages and failures on dams and their appurtenant structures. There is another fact that dams with large reservoirs also trigger earthquake. The results can be more severe if dams are located on or near active fault zones, which are under the influence of more than one energy source.

Earthquake effect on dams depends on dam types. Dam scientists stated that safety concerns for embankment dams subjected to earthquakes involve either the loss of stability due to a loss of strength of the embankment and foundation materials or excessive deformations such as slumping, settlement, cracking and planer or rotational slope failures [1]. According to Jansen [2], safety requirements for concrete dams subjected to dynamic loadings should involve evaluation of the overall stability of the structure, such as verifying its ability to resist induced lateral forces and moments and preventing excessive cracking of the concrete.

In this paper, the seismic hazard and total risk analyses for fifteen large dams located on or near the North Anatolian Fault, are briefly given and their results are comparatively discussed according to new seismic design criteria adopted in Turkey [3]. Some of them has relatively low height and are not on the main rivers of the basin. However, there are high dam with huge reservoirs, which affect all dams in the cascade system of main rivers of the basin. Table 1 introduces the physical properties of dams considered for this study. The author states that the existing large dams, which pose a distance less than 10 km to the NAFZ within the Yesilirmak basin, was selected for the study. In fact, there are more than fifty large dams in the basin.

Table 1: Physical properties of dams considered in the study.

#	Dam	Province	River	Aim (*)	Height from river bed (m)	Completed Year	Type (**)	Volume of embankment (m^3) X1000	Volume of reservoir (hm^3)
1	Almus	Tokat	Yesilirmak	I+F+E	78	1966	EF	3 405	950
2	Atakoy	Tokat	Yesilirmak	E	22	1977	EF	600	2.8
3	Boztepe	Tokat	Boztepe	I	27	1983	EF	1 150	14.2
4	Camlıgoze	Sivas	Kelkit	E	32	1998	RF	2 200	59.0
5	Degirmendere	Amasya	Degirmendere	D	53	2012	RF	1 568	35.0
6	Golova	Sivas	Cobanli	I	22	1990	EF	1 300	65.0
7	Kilickaya	Sivas	Kelkit	E+F+I	103	1990	RF	7 000	1 400
8	Koyulhisar (***)	Sivas	Kelkit	E	20	2009	CG	-	-
9	Sureyyabey	Yozgat	Cekerek	E+F+I	103	2013	RF	7 500	1 310
10	Tepekisla	Tokat	Kelkit	E	50	2015	RF+CG	750	33.0
11	Ulukoy	Amasya	Derebey	I	28	1983	EF	1 131	3.65
12	Vezirkopru	Samsun	Istavloz	I	75	2005	RF	2 570	51.47
13	Yassical	Amasya	Yassical	I	30	2004	RF	200	0.49
14	Yedikir	Amasya	Tersakan	I	28	1985	EF	1 630	60.30
15	Ziyaret	Amasya	Ziyaret	I	55	2005	RF	300	1.75

(*) E = Energy I = Irrigation F= Flood control
(**) EF =Earthfill RF = Rockfill CG = Concrete Gravity
(***) RPP = River Power Plant

2. Material and Methodology

Seismic study includes deterministic and probabilistic seismic hazard analyses for the dams considered for this study. The deterministic seismic hazard analysis considers a seismic scenario that includes a four-step process. It is a very simple procedure and gives rational solutions for large dams because it provides a straightforward framework for the evaluation of the worst ground motions. Krinitzsky [4] states that deterministic seismic hazard analysis considers geology and seismic history to identify earthquake sources and to interpret the strongest earthquake with regardless of time. The probabilistic seismic hazard analysis is widely used and considers uncertainties in size, location and recurrence rate of earthquakes. Kramer [5] states that the probabilistic seismic hazard analysis provides a framework in which uncertainties can be identified and combined in a rational manner to provide a more complete picture of the seismic hazard.

Due to the unavailability of strong motion records, various attenuation relationships were adopted to calculate the peak ground acceleration (PGA) acting on dam sites. For this study five separate predictive relationships for horizontal peak ground acceleration were considered [6, 7, 8, 9, 10]. For the hazard analysis of dam sites, all possible seismic sources were identified and their potential was evaluated in detail, as based on the guidelines given by Fraser and Howard [11] and the unified seismic hazard modelling for Mediterranean region introduced by Jiminez et al [12]. The data instrumentally recorded earthquakes for Turkey and vicinity collected by the National Disaster Organization were considered as a basis for the seismic hazard analyses. The earthquakes that occurred within the last 100 years were used for estimating seismic parameters. Throughout the study, seismic zones and earthquakes within the area having a radius of 100 km around the dam site were considered.

ICOLD [13] recently defined the Maximum Credible Earthquake (MCE) and the Safety Evaluation Earthquake (SEE). In this study, earthquake definitions given by FEMA [14] were considered. Most of large dams in Turkey were analyzed by using these definitions [15]-[34].

Total risk factor of dams can be quantified by various methods. One of them, recommended by ICOLD [36], considers the seismic hazard of the dam site and the risk rating of the structure separately. DSİ Specification considers the ICOLD method for total risk of dams [3]. Another of total risk classification is Bureau method, which considers various risk factors and weighting points to quantify the total risk factor (TRF) of any dam. Bureau states that TRF depends on the dam type, age, size, downstream risk and vulnerability, which based on the seismic hazard of the site [37].

3. Seismic Hazard Analyses

Tosun [38, 39] states that the investigation area has a very complex geology and also a very active seismicity (Fig.1). The geological setting and the data used in the analysis are based on study of Bozkurt [40]. Dam locations are very close to the North-Anatolian Fault Zone (NAFZ), which is a large transform fault between the Eurasian and Anatolian plates sliding past each other. Main segment of the fault was developed in early Pliocene. The NAFZ, which is famous structural feature that produces deathful earthquake, has well developed surface expressions and geological features along its offsets. *T*he NAFZ extends from east Turkey to north Greece. It has a length more than 1500 km and a wide shear zone along its alignment and moves to west with a rate of 24 mm per year

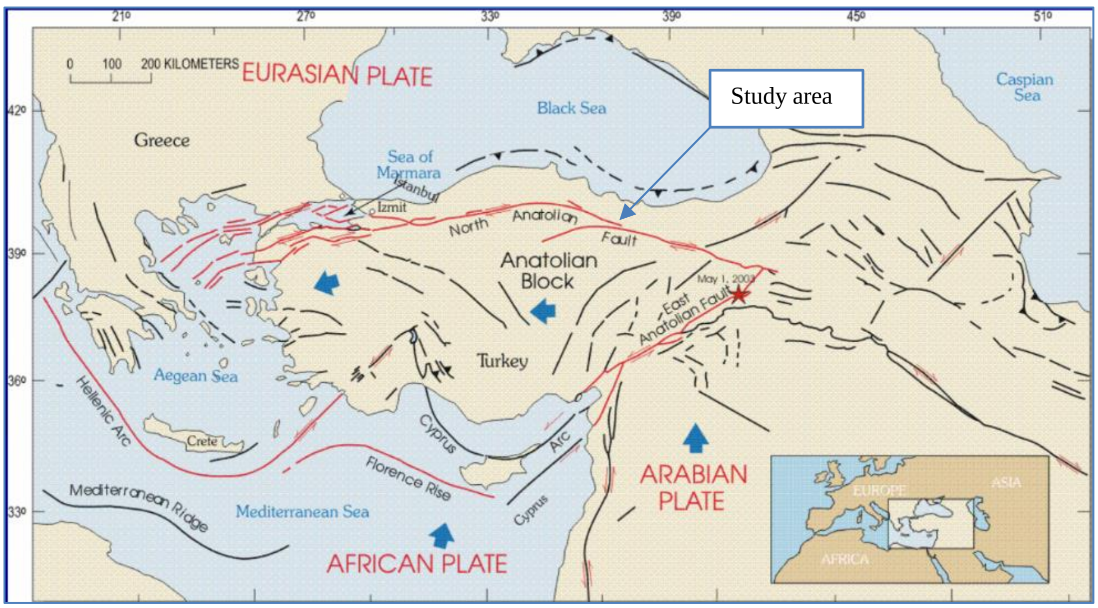

Fig. 1: Neotectonics of Turkey and the study area [40].

In Turkey, a seismo-tectonic map was released to public by National Geological Survey [41]. According to this map, all existing dams considered for this study are under near-field motion. Fig.2 shows the location of dams considered for this study on the updated active fault of Turkey. ICOLD [13] defined the near-field motion, which is ground motion recorded in the vicinity of a fault. In this specification, a correlation between radius of near field area and earthquake magnitude is suggested as based on the cases on West United States. Author established limits of near-field motion for the investigation area. According to this model, the maximum magnitude of the earthquakes is same for major dams (Mw = 7.4) and the minimal distance to fault segment is between 0.58 and 9.90 km (Table 3). However, the major segments of NAFZ cut some embankments and reservoirs for the dams in context of this study.

Fig. 2: The dams located on the active fault map of Turkey (Active faults-yellow color: earthquake surface fracture, red color: Holocene fault, purple color: Quaternary fault, black color: possible Quaternary fault).

The deterministic analyses indicate that peak ground acceleration (PGA) values ranges from 0.160g to 0.514g at the 50^{th} percentile and from 0.398g to 0.847g at the 84^{th} percentile given in Table 2. The probabilistic hazard analyses give PGA values within a narrow range. the MDE values are between 0.316g and 0.575g, while the OBE values ranges from 0.193g to 0.318g. According to the DSI guidelines, designers have to use the PGA values at the 84^{th} percentile for the dams having high and extremely high hazard classes, when considered deterministic approach.

4. Total Risk Analyses

According to DSI Guidelines three dams (Atakoy, Yassical and Ziyaret) are categorized in the risk class of II with moderate risk ratio, while five dams (Boztepe, Degirmendere, Golova, Koyulhisar and Yedikir) are in the risk class of III with a high-risk ratio. The rest are seven dams (Almus, Camligoze, Kilickaya, Sureyyabey, Tepekisla, Ulukoy and Vezirkopru), which are classified into the risk class of IV with extremely high-risk ratio (Table 3). Following Bureau's method, all large dams with exception of two dams (Yassical and Ziyaret) are classified in risk class III with a high-risk ratio. The author thinks that the results obtained from Bureau method is more rational than those estimated by the DSI guidelines.

5. Discussion

Earthquake safety of dams requires more comprehensive seismic studies for understanding the seismic behavior of dams subjected to severe earthquakes. It is a well-known phenomenon that earthquakes can result damages and failures for dams and their appurtenant structures. There is another fact that dams with large reservoirs also trigger earthquake [42]. Results can be more severe if dams are located on or near active fault zones, which are under the influence of more than one energy source. Therefore, the dams located on and close to the NAFZ can result to danger conditions for public safety. As discussed throughout this study, the dams are under near-field motion, and most of them are also under threat of more than one energy sources.

Table 3: Results of seismic hazard analysis (*).

#	Dam	Deterministic Method *				Probabilistic Method **		
		M_{max}	R_{min}	Mean PGA + 50 %	Mean PGA + 84 %	OBE in g	MDE in g	SEE in g
1	Almus	7.4	9.80	0.302	0.497	0.256	0.380	0.575
2	Atakoy	7.4	9.00	0.312	0.514	0.244	0.359	0.541
3	Boztepe	6.6	9.08	0.235	0.398	0.236	0.352	0.533
4	Camlıgoze	7.4	2.99	0.467	0.771	0.230	0.358	0.562
5	Degirmendere	7.0	1.89	0.407	0.681	0.263	0.393	0.611
6	Golova	7.4	2.51	0.477	0.789	0.256	0.383	0.580
7	Kılıckaya	7.4	7.81	0.354	0.583	0.193	0.295	0.453
8	Koyulhisar	7.4	1.30	0.501	0.827	0.243	0.384	0.609
9	Sureyyabey	6.7	9.21	0.240	0.404	0.209	0.322	0.499
10	Tepekisla	7.4	1.46	0.493	0.814	0.211	0.316	0.483
11	Ulukoy	7.4	0.58	0.514	0.847	0.381	0.575	0.885
12	Vezirkopru	7.4	2.60	0.474	0.782	0.380	0.561	0.848
13	Yassical	6.8	9.90	0.160	0.267	0.274	0.401	0.599
14	Yedikır	7.0	0.94	0.445	0.743	0.259	0.414	0.676
15	Ziyaret	6.8	5.45	0.326	0.548	0.266	0.399	0.615

(*) Note: M_{max} = Maximum earthquake magnitude in M_w, R_{min} = Minimum distance to fault segment, Mean PGA + 50% = Mean Peak Ground Acceleration at the 50^{th} percentile, Mean PGA + 84% = Mean Peak Ground Acceleration at the 84^{th} percentile, OBE= Operational Based Earthquake, MDE = Maximum Design Earthquake, SEE = Safety Evaluation Earthquake

Table 3: The results of total risk analysis.

#	Dam	PGA in g	M_{max}	Hazard Analysis		Total Risk (ICOLD,1989)			Total Risk (Bureau, 2003)		
				Class	Hazard Ratio	Risk factor	Risk class	Risk ratio	Risk factor	Risk class	Risk ratio
1	Almus	0.302	7.4	IV	Extremely high	36	IV	Very high	229.0	III	High
2	Atakoy	0.312	7.4	IV	Extremely high	18	II	Moderate	129.5	III	High
3	Boztepe	0.235	6.6	II	Moderate	22	III	High	151.3	III	High
4	Camligoze	0.467	7.4	IV	Extremely high	32	IV	Very high	164.8	III	High
5	Degirmendere	0.407	7.0	IV	Extremely high	22	III	High	151.3	III	High
6	Golova	0.477	7.4	IV	Extremely high	30	III	High	218.7	III	High
7	Kilickaya	0.354	7.4	IV	Extremely high	36	IV	Very high	168.7	III	High
8	Koyuhisar	0.501	7.4	IV	Extremely high	26	III	High	138.4	III	High
9	Sureyyabey	0.240	6.7	II	Moderate	36	IV	Very high	144.3	III	High
10	Tepekisla	0.493	7.4	IV	Extremely high	34	IV	Very high	161.1	III	High
11	Ulukoy	0.514	7.4	IV	Extremely high	22	IV	High	129.5	III	High
12	Vezirkopru	0.474	7.4	IV	Extremely high	34	IV	Very high	160.4	III	High
13	Yassical	0.160	6.8	II	Moderate	12	II	Moderate	63.8	II	Moderate
14	Yedikir	0.445	7.4	IV	Extremely high	30	III	High	217.6	III	High
15	Ziyaret	0.326	6.8	IV	Extremely high	18	II	Moderate	78.1	II	Moderate

Throughout this study, the seismic hazard analyses were performed for fifteen dams which are under threat of the North Anatolian Fault and its secondary segments. The deterministic analyses indicate that peak ground acceleration (PGA) change with a wide range (from 0.160g to 0.514g at the 50th percentile and from 0.398g to 0.847g at the 84th percentile) . The probabilistic hazard analyses introduce PGA values within a relatively narrow range (the MDE values are between 0.316g and 0.575g, and the OBE values are between 0.193g to 0.318g). The maximum values obtained from deterministic hazard analysis belongs to the dam embankment cut by an active fault. For example, the embankment of Ulukoy dam and the reservoirs of Yedikir and Kilickaya dams are cut by the main segments of NAFZ. Fig.3 shows the location of Ulukoy dam's embankment under which an active fault (the main segment of NAFZ) is passing. For the most critical dams in Yesilirmak basin, detail deformation and stress analyses should be performed and also liquefaction susceptibility should be clarified for the foundation and embankment materials as considering actual data [43, 44].

Fig. 3: The location of Ulukoy dam on active fault map (yellow line represents the main segment of NAFZ).

7. Conclusion

The investigation area is located around NAFZ at mid-Anatolia of Turkey. In this study, fifteen dams having a hydraulic height between 20 and 103 m, namely Almus, Atakoy, Boztepe, Camlıgoze, Degirmendere, Golova, Kilickaya, Koyulhisar, Sureyyabey, Tepekisla, Ulukoy, Vezirkopru, Yassical, Yedikır and Ziyaret dams, were considered. These dams are very close to the main zone of NAFZ or its segments. The seismic hazard analyses have indicated that peak ground acceleration changes within a wide range (0.570 g and 0.859 g) for the fifteen dam sites of this region. The TRF data range from 84.16 to 229.0 based on the Bureau method. This means that all dams with exception of two small ones are classified into the risk-class of III. In other words, eighty-seven percent of dams are identified as a risk class of III with high risk ratio. Especially, Almus, Kilickaya, Süreyyabey and Vezirkopru dams are the critical structures for public safety of downstream life and for overall stability of cascade system in Yesilirmak basin. The embankment of Ulukoy dam and the reservoirs of Yedikir and Kilickaya dams are cut by the main segments of NAFZ. The Almus dam, which has 45-years old, is most critical structure between the dams located on Yesilirmak basin at mid-Anatolia, Turkey. The maximum TFR value belongs to this dam. Therefore, the dams, which are under near-field motion of the North Anatolian Fault Zone, must be analyzed with high priority under a well-defined dam safety program and re-designed to increase the safety of the embankments and their appurtenant structures, if necessary.

References

[1] M.Wieland., "Seismic hazard and seismic design and safety aspects of large dam projects." *In proceeding s of the Second European Conference on Earthquake Engineering and Seismology,* Istanbul, Aug. 25-29, 2014.

[2] R.B.Jansen (Ed.), *Advanced Dam Engineering for Design Construction and Rehabilitation*. Van Nostrand Reinhold, New York 884 pp. 1988

[3] DSİ, *Selection of Seismic Parameters for Dam Design, State Hydraulic Works*. Ankara, 29 p, 2012 (in Turkish).

[4] E.Krinitzsky, "Discussion on Problems in the Application of the SSHAC Probability Method for Assessing Earthquake Hazards at Swiss nuclear power plants". *Eng. Geol. 78 285-307; Eng.Geo.* 82, 62-68. 2005.J. P. Wilkinson, "Nonlinear resonant circuit devices," U.S. Patent 3 624 125, July 16, 1990.

[5] S.L.Kramer, *Geotechnical Earthquake Engineering*. *Prentice-Hall, Upper Saddle River*, NJ 653 p, 1996.

[6] K.W. Campbell, "Near-Source Attenuation of Peak Horizontal Acceleration" *Bulletin Seism. Soc. Am.,* V.71, N.6, pp. 2039-2070, 1981.

[7] D.M.Boore, W.B. Joyner, T.E.Fumal, "Equation for Estimating Horizontal Response Spectra and Peak Acceleration from Western North American Earthquakes*", A Summary of recent Work. Seismological Research Letters,* V.68, N.1, January /February, pp. 128-153, 1997.

[8] P.Gulkan, E.Kalkan, "Attenuation modeling of recent earthquakes in Turkey*", Journal of Seismology*, vol.6, no. 3, pp. 397-409, 2002.

[9] E.Kalkan, P.Gulkan, "Site-Dependent Spectra Derived from Ground Motion Records in Turkey", *Earthquake Spectra*, 20, 4, 1111-1138, 2004.

[10] N.N.Ambraseys, J.Douglas, S.K. Karma & P.M.Smit, "*Equations for the Estimation of Strong Ground Motions from Shallow Crustal Earthquakes Using Data from Europe and the Middle East- Horizontal Peak Ground Acceleration and Spectral Acceleration"* Bulletin of Earthquake Engineering, 3, pp. 1-53, 2005.

[11] W.A.Fraser, J.K.Howard, *Guidelines for Use of the Consequence-Hazard matrix and Selection of Ground Motion Parameters*. Technical Publication, Department of Water Resources, Division of Safety of Dams, 2002.

[12] M.J.Jiminez, D.Giardini, G.Grünthal, "Unified Seismic Hazard Modelling throughout the Mediterranean Region*", Bolettino di Geofisica Teorica ed Applicata*, Vol.42, N.1-2, Mar-Jun., pp. 3-18., 2001.

[13] ICOLD, *Selecting Seismic Parameters for Large Dams-Guideline*. *ICOLD*, Bulletin 148, 2016.

[14] FEMA, *Federal Guidelines for Dam Safety—Earthquake Analyses and Design of Dams. 2005*.

[15] H. Tosun, "Seismic studies", *International Water Power & Dam Construction,* vol. 58, no. 2, pp. 20-23, 2006.

[16] H.Tosun, İ. Zorluer, A.Orhan, E.Seyrek, H.Savaş, M.Türköz, "Seismic hazard and total risk analyses for large dams in Euphrates basin, Turkey", *Engineering Geology* 89 (1-2), pp. 155-170, 2007.

[17] H.Tosun, "Total Risk Analysis of Dam and Appurtenant Structures in a Basin and a Case Study" International Congress in River Basin Management, Volume I, 22-24 March, Antalya, pp. 477-488, 2007.

[18] H.Tosun,M. Türkoz, & H.Savas, *River basin risk analysis*. Int. Water Power and Dam Construction, May issue, 2007.

[19] H. Tosun, "Evaluating Earthquake Safety for Large Dams in Southeast Turkey", *Hydro Review Worldwide (HRW),* pp. 34-40, 2008.

[20] H.Tosun, T.V.Tosun, Total risk and seismic hazard analyses of large dams in northwest Anatolia, Turkey. ICOLD 85th Annual Meeting, July 3-7, Prague, 2017.

[21] H.Tosun, T.V.Tosun, M.A. Hariri-Ardebili, "Total risk and seismic hazard analysis of large embankment dams: case study of Northwest Anatolia, Turkey" *Life Cycle Reliability and Safety Engineering*, 1-10, 2020 (https://doi.org/10.1007/s41872-020-00113-4).

[22] H.Tosun, H.Savas, "Seismic hazard analyses of concrete dams in Turkey", *in Proceeding of CDA Conference*, 2005.

[23] H. Tosun, "Earthquakes and dams" *in charter of Earthquake Engineering (edited by A.Moustafa*), Chapter 7, Intechopen, pp. 189-198, 2015, http://dx.doi.org/10.5772/59372

[24] H.Tosun, M.Turkoz, S.Savas, E.Seyrek, "River basin risk analysis", *International Water Power and Dam Construction*, vol. 59, no. 5, p. 30, 2007.
[25] H.Tosun, M.Turkoz, "Total risk-analyzing methods for dam structures and a case study in Turkey", *in Proceeding of CDA Annual Conference*, 2007.
[26] H.Tosun, E.Seyrek, "Total risk analyses for large dams in Kizilirmak basin, Turkey", *Natural Hazards and Earth System Sciences*, vol. 10, no. 5, p. 979, 2010.
[27] E.Seyrek, H.Tosun, "Deterministic approach to the seismic hazard of dam sites in Kızılırmak basin, Turkey" *Natural hazards*, vol. 59, no. 2, p. 787, 2011.
[28] H.Tosun, "Re-analysis of Ataturk Dam under Ground Shaking By Finite Element Models", *in Proceeding of CDA Annual Conference*, September 22-27. Saskatoon, Canada, 2011.
[29] H.Tosun, "Earthquake Safety of Keban Dam, Turkey", *in Proceeding of CDA Annual Conference*, October 15-20. Fredericton, NB, Canada, 2012.
[30] E.Seyrek, H.Tosun, "Influence of analysis methods for seismic hazard on total risk of large concrete dams in Turkey", *Gazi Univ, J.Fac Engineering Architecture*, 28-1, pp. 67-75, 2013.
[31] H.Tosun, S.Oguz, "Stability Analysis of Atatürk dam, Turkey as Based on the Updated Seismic Data and Design Code", *in Proceeding of 85th Annual Meeting of International Commission on Large Dams*, Prague, 66-66, 2017.
[32] T.V. Tosun, H.Tosun, "Total Risk and seismic hazard analyses of large dams in Northwest Anatolia, Turkey" *in Proceeding of 85th Annual Meeting of International Commission on Large Dams*, Prague, pp. 165-165, 2017.
[33] H Tosun, T.V Tosun "Dynamic Analysis of Embankment Dams Under Strong Seismic Excitation and a Case Study", *in Proceeding of Long-Term Behaviour and Environmentally Friendly Rehabilitation Technologies of Dams (*LTBD 2017), Tehran, 2017, DOI:10.3217/978-3-85125-564-5-102.
[34] H.Tosun, "Safety Assessment of Large Reservoir Constructed for Domestic Water Near Urban Areas and a Case Study", *in Proceeding of ICOLD-ATCOLD Symposium on Hydro Engineering*, Wien, pp. 917-927, 2018
[35] H.Tosun, T.Mirata, M.Mollamahmutoglu, and N.S.Colakoglu, " Shear strength of gravel and rockfill measured in triaxial and prismatic wedge shear tests" *Electronic Journal of Geotechnical Engineering*, EJGE Paper 9903, 1999
[36] ICOLD, "Selecting Parameters for Large Dams-Guidelines and Recommendations*", ICOLD Committee on Seismic Aspects of Large Dams*, Bulletin 72, 1989.
[37] G.J. Bureau, "*Dams and Appurtenant Facilities in Earthquake Engineering Handbook"* edited by Chenh, W.F and Scawthorn,C. CRS press, Bora Raton 26.1-26.47, 2003.
[38] H.Tosun, "Seismic Stability of Large Dams Located Near Energy Source And A Case Study" *in Proceeding of 5th International Conference on Earthquake Engineering and Seismology,* METU-Ankara 8-11 October 2019.
[39] H.Tosun, "Earthquake Safety Evaluation for Large Dams Located near the Energy Source and Case Studies", *in Proceeding of 11th ICOLD Europen Clup Symposium, Chania, Crete, 2-4 October 2019.*
[40] Bozkurt,E. 2001. Neotectonics of Turkey—a synthesis. Geodinamica Acta, 14. 2001, pp. 3–30.
[41] General Directorate Of Mineral Research And Explorations (MTA), Geoscience Map Viewer and Drawing Editor, http://yerbilimleri.mta.gov.tr/
[42] H.Tosun, "Earthquakes and Dams", *in Earthquake Engineering - From Engineering Seismology to Optimal Seismic Design of Engineering Structures, edited by Abbas Moustafa, IntechOpen*, May 2015, (DOI: 10.5772/59372).
[43] H.Tosun, M.Turkoz, H.Savas and E.Igdirsel "Deformation and stress analysis of concrete-faced rockfill dam by finite element method and a case study" *Seminar on Dam and Earthquake*, May 11-12, Eskisehir Osmangazi University, 2006 (in Turkish).
[44] H.Tosun and R.Ulusay. "Engineering Geological Characterization and Evaluation of Liquefaction Susceptibility of Foundation Soils at a Dam Site, Southwest Turkey" *Environmental and Engineering Geoscience*, III (3): pp. 389–409, 1997.