



The performance of transmission pipelines on February 6th, 2023 Kahramanmaras earthquake: a series of case studies

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Abstract

The M_w 7.8 earthquake that struck Kahramanmaras on February 6, 2023, caused significant damage to hydrocarbon and water transmission lines due to permanent ground deformations. Explosions occurred in the Kahramanmaras–Gaziantep Natural Gas transmission pipeline causing disruption of gas in the cities of Gaziantep and Hatay Fault Displacement Hazard. Water transmission pipelines were also damaged due to extreme fault offsets. This paper presents the findings from the earthquake affected zones. Particular attention was given to the performance of the 2600 mm diameter Duzbag–Gaziantep water transmission pipeline due to three reported challenges: (#1) The behavior of the pipe in the Duzbag tunnel, (#2) The pipe bend behavior at the fault crossing, and (#3) The pull-out of the pipe at valve room. Based on field observations, extreme damage forms at pipes were presented. A three-dimensional nonlinear numerical analysis was performed to simulate the observed damage of the reoriented water pipe at the fault crossing for Case #2. The nonlinear finite element model was able to capture the complex nature of the post-yield behavior of steel pipe as well as the damage locations along the pipe and their sequence of occurrences. As a mitigation measure for new pipes, the need for using flexible connections at critical crossings was highlighted. For existing pipes, the importance of developing secondary (by-pass) lines was emphasized.

Keywords Kahramanmaras earthquake · Water · Hydrocarbon · Transmission pipelines · Fault crossings · Fault displacement hazard

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1 Introduction

On February 6, 2023, a $M_w=7.8$ earthquake struck near Pazarcik City, Kahramanmaraş, in south-central Türkiye causing extensive damage in the pipeline infrastructure in the earthquake affected region. A second earthquake ($M_w=7.5$) which was probably triggered by the first one, struck the nearby city Elbistan on the same day. The first earthquake was associated with a left lateral strike slip, and it was ruptured bi-laterally for about 350.0 kms along the East Anatolian Fault (EAF). Maximum fault offset was 10.0 m. The recorded Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV) were 1.4 g and 1.8 m/s, respectively, due to the soil amplification, fault directivity and basin effects (Erdik 2023). Figure 1 shows the hydrocarbon and water transmission pipeline routes overlaid on the PGV map and the surface rupture line. The geology and the areas of interest (zones 1–3) of the Golbasi basin are also shown in the same figure.

The main focus of this research article is to investigate the performance of hydrocarbon and water transmission pipes under FDH in the $M_w=7.8$ earthquake. The results of the reconnaissance survey, case studies, design philosophy of buried steel pipes and numerical simulation of a large diameter pipeline due fault displacement hazard (FDH) are also presented. Possible causes of damage to buried pipelines are elaborated.

Hydrocarbon transmission pipelines in the earthquake-affected region consisted of Natural Gas (NG), Crude Oil (CO) and Fuel Oil (FO) pipes. As seen in Fig. 1, the NG pipeline was closely spaced and laid almost parallel to the EAF. It suffered extensive

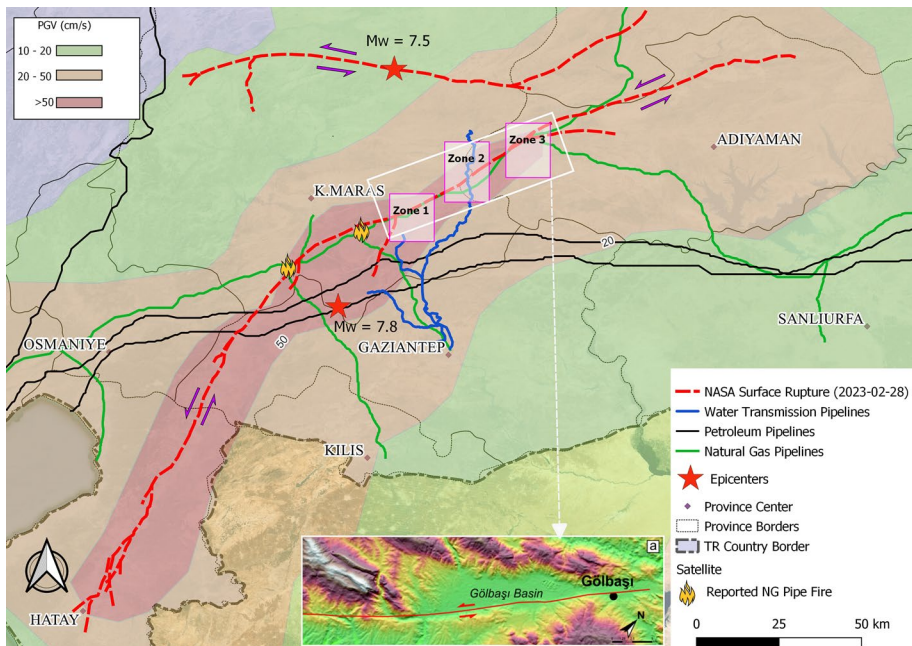


Fig. 1 The routes of the hydrocarbon and water transmission pipelines, the EAF line, the epicenter of the earthquake, PGV map and geological map of the Golbasi Basin including geomorphology (Yönlü et al. 2017) Zone 1: Hydrocarbon damage, Zone 2: Water line damages Zone 3: Manhole floats due to liquefaction

damage due to fault offsets at different points. Two explosions occurred in the K. Maras-Gaziantep and as a result, gas outages occurred in the cities of Gaziantep and Hatay.

Unlike water lines, exact digital data was not available for hydrocarbon lines. Therefore, they were reconstructed using available low-resolution raster images. Approximate routes of hydrocarbon lines, explosion locations, fault crossing points and critical zones (1) are shown in the same figure.

On the other hand, the exact routes of the water line were available. As seen in the figure, Duzbag–Gaziantep water transmission line was crossing the EAF at a single point near Sogutlu village (*Zone 2*). Due to excessive fault offset, the pipeline ruptured and was therefore out of service for several weeks. There were two other functional lines feeding the city. Therefore, the water system remained almost operational, hence water was provided within two days in the city of Gaziantep.

Based on data provided from NASA (National Aeronautics and Space Administration 2023a, b) the variation of the FDH along the EAF is shown in Fig. 2. As can be seen in the map, surface ruptures were observed to be up to 10.0 m in some off-site areas. Considering that the slip rate of the EAF is 5.5 mm per year, the average Failure Displacement Hazard (FDH) during the 900-year return period can be estimated to be 5.0 m. This was consistent with field observations (Yönlü et al. 2017) in *zone 2*, shown in the Fig. 1. Besides FDH, the region was also prone to spatial PGDs due to liquefaction induced lateral spreading and landslides. Widespread ground failures occurred in the earthquake effected region due to liquefaction hazard.

In Fig. 3, the liquefaction potential map obtained from NASA satellite data (National Aeronautics and Space Administration 2023b), the routes of transmission pipelines (National Aeronautics and Space Administration 2023a) and pipe damages due to PGD are shown. It is seen that liquefaction hazard concentrated in the southern regions of the

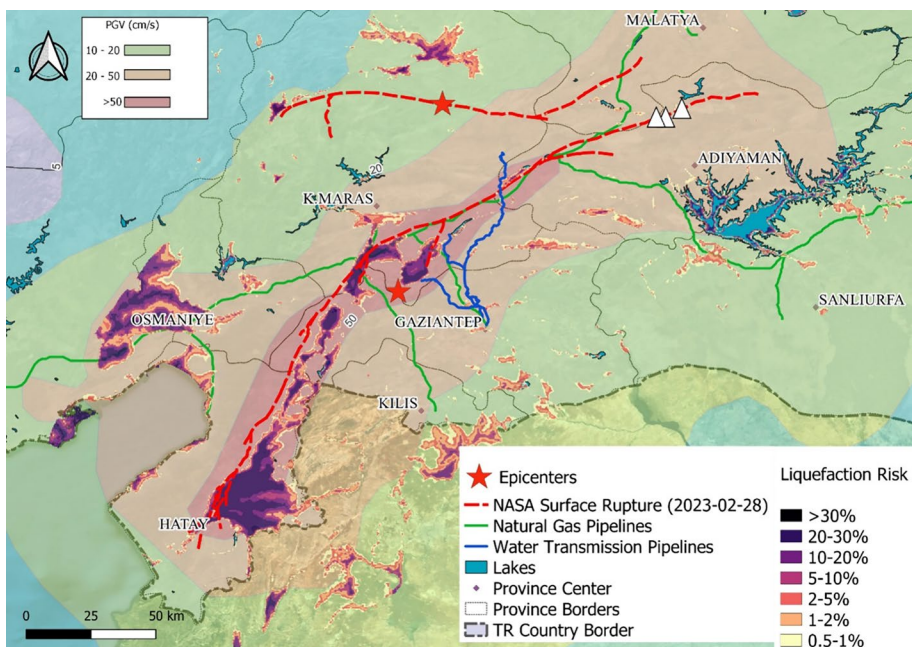


Fig. 2 The FDH map provided from NASA and the routes of transmission pipelines

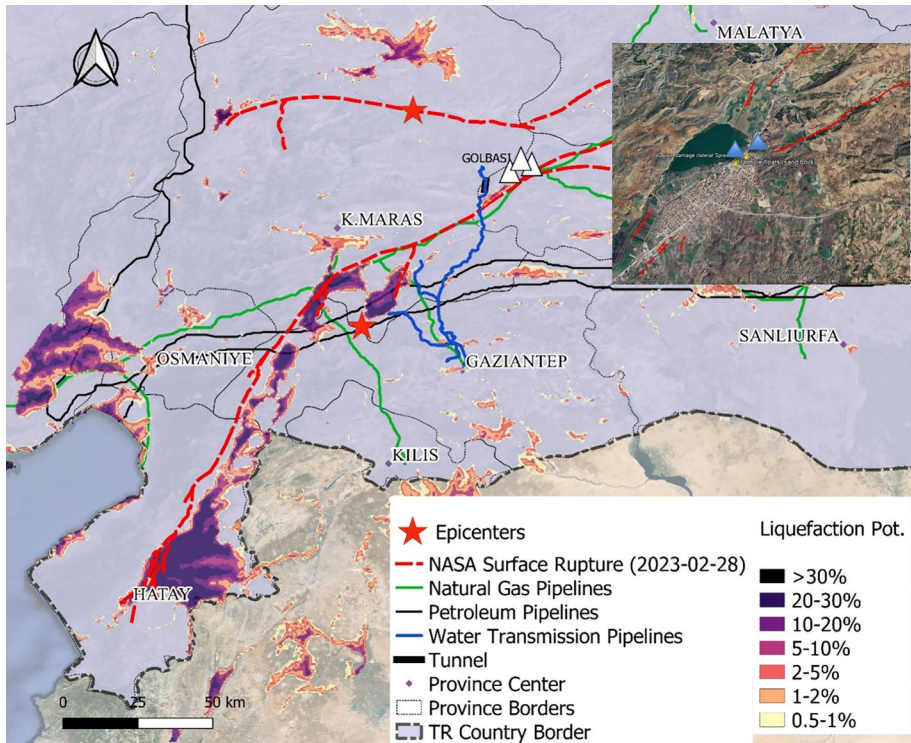


Fig. 3 Liquefaction potential around the EAF line (National Aeronautics and Space Administration 2023a) manhole floating and NG damage due to liquefaction lateral spreading in Golbasi

fault line, nearby Hatay and Turkoglu. The field reconnaissance survey was mainly conducted in the northern region. Pipe damages were also observed due to liquefaction hazard in the Golbasi region. Detailed information about these damages is provided in the following section.

2 Design philosophy of buried steel pipes under earthquakes and faulting action (FDH)

Under the influence of earthquakes, buried pipes can be subjected to large bending stresses and tensile loads. Potential earthquake hazards to buried pipelines include transient wave propagation (WP) and permanent ground displacement (PGD). Ground deformations caused by WP are generally lower than deformations caused by PGD so that damage rates are lower than PGD but are generally effective over larger areas, such as distribution networks in urban areas. Such approaches are frequently used in earthquake urban master planning to estimate spatial variation of damage rates in distribution networks for post-earthquake recovery efforts, mostly in urban areas. Empirical fragility relationships for buried pipes are defined in terms of the expected number of damages (damage rate) per km of Maximum Ground Velocity (PGV) or Peak

Ground Strain (PGS). The axial strain, ϵ_a , induced in a buried pipe by wave propagation can be approximated using the following equation (ALA 2001):

$$\epsilon_a = \frac{V_g}{\alpha C_s} \quad (1)$$

where V_g : peak ground velocity generated by shaking. C_s : apparent propagation velocity for seismic waves (conservatively to be 2 km per second). α : 2.0 for C_s associated with shear waves, 1.0 otherwise.

Considering that the maximum PGV recorded in the K. Maras earthquake was approximately 1.8 m/s, assuming that in the near-fault body waves dominate ($\alpha=2.0$), pipe axial strain can be calculated as 0.0005, which is well below the buckling strain of steel pipe. On the other hand, long and buried structures such as pipelines and tunnels are prone to damage mainly due to permanent ground deformation (PGDs) caused by liquefaction or fault displacement hazard (FDH). PGDs can usually cause localized damage to pipelines but with higher damage rates compared to the WP hazard (Nowicki Jessee et al. 2018; Toprak et al. 2015; Uckan 2014; Banushi et al. 2018; O'Rourke et al. 2015). Among these, the fault displacement hazard (FDH) can be considered one of the most critical one since it might result in large axial and bending strains along buried pipelines hence can cause damage in high quality transmission lines as well. Since the possible locations of surface ruptures are generally known, one can precisely estimate the post elastic response of the pipes by utilizing FE models, hence, the application of rational damage mitigation measures can be possible.

The design philosophy of buried pipes under faulting action is based on promoting tension failure. This is due to the fact that the tensile strain capacity of steel pipe is larger than compressive strain capacity. To meet this criterion, the first step is to maintain nominal tension in the pipe by adjusting the orientation angle of the pipe with respect to the fault line.

Depending on the crossing angle between the pipe axis, fault line and slip direction (left or right lateral a strike slip fault) can cause either nominal tension or nominal compression in the pipeline (Fig. 4). For example, when the angle (β) between the pipe normal and fault line is less than 90 degrees the left lateral fault slip cause shortening in the pipe whereas the same fault offset would result in nominal tension in case of a right lateral fault offset (negative crossing angle). It is important to mention that maintaining the nominal tension does not necessarily guarantee tension failure in steel pipe. This is because the pipe will also be distressed due to bending as a result of the transverse component of the fault displacement that will impose compressive strains in pipe.

Considering a pipe with a crossing angle of 90 degrees, under the progressive application of the fault displacement, compressive strains increase in small fault displacements. Whereas they tend to decrease in large displacements due to the stretching (second order effects) of the pipe (O'Rourke et al. 2015). Therefore, soil backfill material, D/t ratio, burial depth, steel grade and pipe wall thickness and etc. should be arranged such that the maximum compressive strain does not exceed the buckling strain of the pipe.

ALA (2001), Eurocode 8 (Standard British 2005) and the recent Turkish guidelines (Turkish Standardization Institute (TSE) 2019) address the performance criteria and damage limit states of buried pipes. The tensile strain limits of the pipes are usually considered to be 2% and 5% for 10% and 90% probabilities of failure, respectively. Limit conditions for performance-based design of buried pipes are also mentioned in the recent Turkish guidelines.

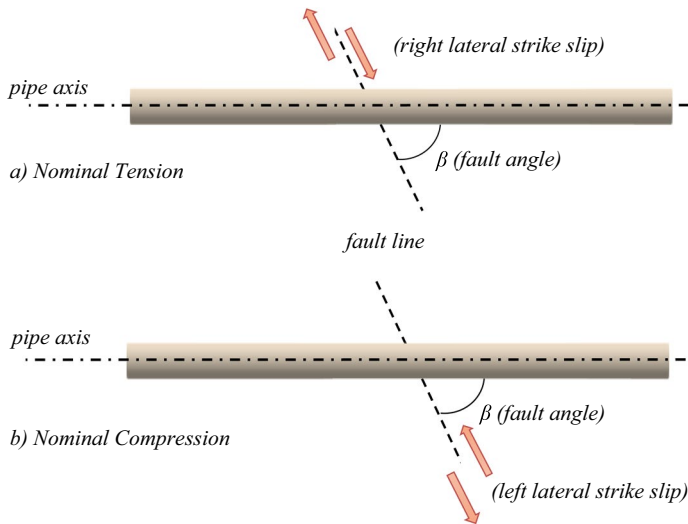


Fig. 4 Schematic representation of strike slip fault and crossing pipe axis

As observed in recent earthquakes, it may not be possible to avoid premature damage to steel pipes with conventional design due to the combined effects of fault mapping uncertainty, forced route selection, and excessive fault offsets. For this reason, despite its high ductility, wall fractures, wrinkling and reductions in pipe diameter may inevitably occur in the pipe. For such critical situations, it is of great importance to develop special solutions such as flexible connections that will compensate for the axial displacement and rotation demands that will occur at plastic joint locations.

3 Field reconnaissance

An exploration team from Alanya Alaaddin Keykubat University, with the support of TUBITAK (Scientific and Technological Research Council of Türkiye), contacted representatives of municipalities, public service companies and related organizations to investigate the seismic performances of water and hydrocarbon facilities (TUBITAK Field Survey Report 2023). The primary objective of the field trip was to identify critical regions of fault crossings. Prior to the trip, actual fault maps were overlaid on hydrocarbon lines to identify potential areas of compression zones that could create unfavorable conditions for pipes (Fig. 5).

3.1 Hydrocarbon transmission pipes

The hydrocarbon pipeline inventory in the earthquake effected region consist of natural gas (NG), crude oil (CO) and fuel oil pipelines. Limited information could be obtained from pipe operators in terms of both pipe route and pipe damage. Based on available data, it can be seen that NE-SW oriented NG lines along the Golbasi–Turkoglu and Turkoglu–Hatay fault segments run almost parallel to the EAF line for about 100.0 kms. The NG pipelines

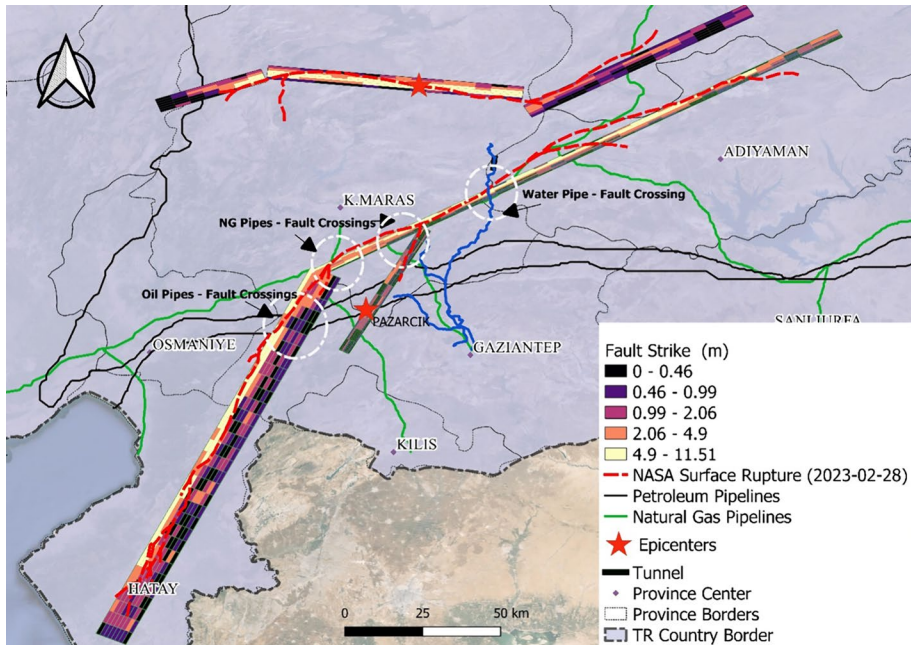


Fig. 5 Fault crossings of natural gas, crude oil and water pipes overlaid on the PGD map provided from NASA

cross the fault line several times with positive or negative orientation angles as can be seen in Fig. 5. The approximate locations of fault crossings and explosions that caused disruption of NG in Gaziantep were also marked.

Figure 5 shows that the CO pipelines intersect the NE-SW oriented EAF at a single point near Nurdagi. In addition, the two NG lines namely, K. Maras-Gaziantep and K. Maras-Kilis cross the EAF and DAF at two points being consistent with reported explosions.

3.2 Observed pipeline damage

Due to PGDs major damage observed in NG pipelines. In many cases, especially under high compressive and tensile loads, wall tears, local buckling, wrinkles and reductions in pipe diameter occurred in the pipe wall despite of the high ductility of pipes as shown in Fig. 6. Pipe damage was also observed in smaller diameter steel NGs transmission pipes due to liquefaction induced lateral spreading in Golbasi (Fig. 7). Lateral spreads were measured up to 60 cm and caused damage mainly to the smaller diameter steel NG pipes in Golbasi region. Some pipes were buckled, broken, or separated due to weld failures as shown in Fig. 8.

When the compressive strains exceeded the limit state of the pipe, wall wrinkling (i.e. local buckling) occur. In such cases, even though the structure becomes unstable due to formation of plastic joints, the ductile pipelines might still be able to function. However, due to the possibility of fatigue failure during the operational safety of the pipeline may not be maintained in the long term.



Fig. 6 Buckling and ovalization of the NG transmission pipelines collected from different fault crossing locations (See lidar file #SF1)



Fig. 7 Liquefaction induced lateral spreading observed in Golbasi (see Fig. 1—zone 3 and Fig. 3)

In addition to continuous steel lines, segmented wastewater pipelines were also seriously damaged due to sand boils as shown in Fig. 9. Due to excessive pore water pressure, upheavelling of sewage pipeline and floating manholes were observed in Golbasi. Their locations are shown in Figs. 1 and 3.

4 A series of case studies: the Duzbag–Gaziantep water transmission line

The 80 km long and 2600 mm of diameter steel water pipeline was one of the three main transmission lines of Gaziantep. It was consisting of support units such as pump rooms, storage tanks, valve rooms and a tunnel passage. During the earthquake, the pipe was exposed to faulting, landslide, and liquefaction hazards at different points along its route from Duzbag to the city of Gaziantep.

The locations of all three cases are shown in Fig. 10. Case #1 refers to the Duzbag Tunnel Passage whereas Case #2 refers to the Sogutlu fault crossing and Case #3 refers to the pullout of the water pipe at the valve room#5.



Fig. 8 Weld failure and buckling of small diameter steel NG pipes due to liquefaction induced lateral spreading observed in Golbasi (see Figs. 1, 3 and 7). (See lidar files #SF2 and #SF3)



Fig. 9 Upheavelling of sewage pipeline and floating manholes due to sand boils in Golbasi (See Figs. 1 and 3)

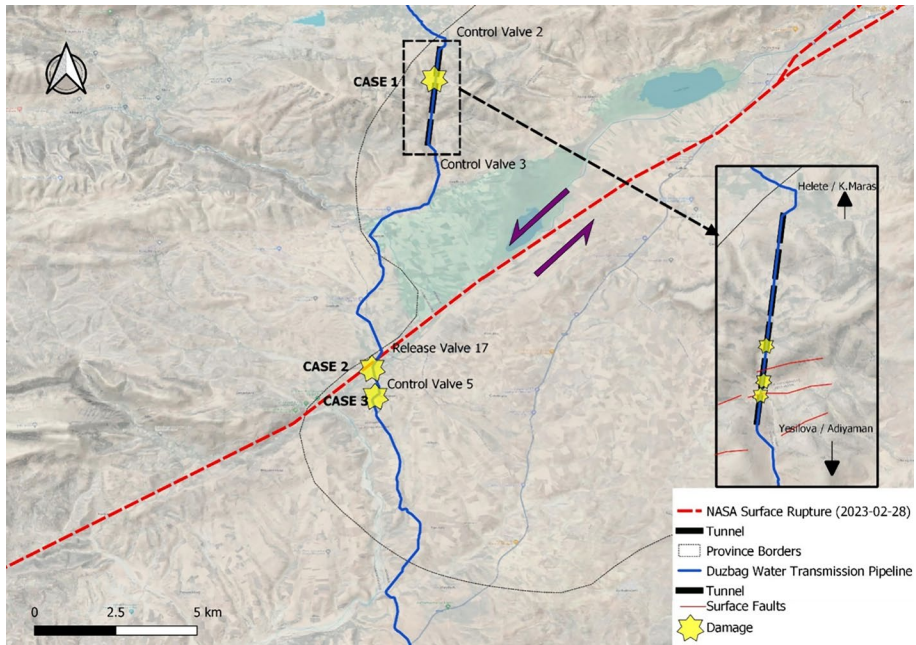


Fig. 10 Damage locations of the Duzbag–Gaziantep transmission line (GASKI 2023)

4.1 Case 1: the Duzbag–Gaziantep tunnel passage

The 3520.0 m long Duzbag tunnel, seen in Fig. 11, is located near Caglayacerit Village of Kahmanmaras. The inner diameter of the tunnel which consists of reinforced concrete lining is 6.3 m. The average depth of the tunnel is 150.0 m, and the deepest part is 300.0 m. As seen in the figure, it is approximately 5.0 km away from the DAF fault and it was under the influence of secondary normal faults that cut its axis perpendicularly as shown in Fig. 11.

The fault lines and damaged locations of the pipeline with profiles and cross-sectional views of the Duzbag tunnel were shown in Figs. 12, 13 and 14, respectively (GASKI 2023).

The water transmission pipeline is placed inside the tunnel. It has been converted into a segmented line by flexible couplings and placed freely on the rollers at the bottom of the tunnel. The tunnel-pipe system was exposed to extension due to normal faulting. The axial displacement demand caused by tectonic movement was compensated by sliding supports placed along the axis (Fig. 13).

After the earthquake, the rollers were seen to display about 15.0 cm due to extension of the pipe. However, no damage was observed in the pipeline. On the other hand, the R/C lining, while protecting the pipeline from the tectonic action, was damaged at three points as shown in Fig. 14.

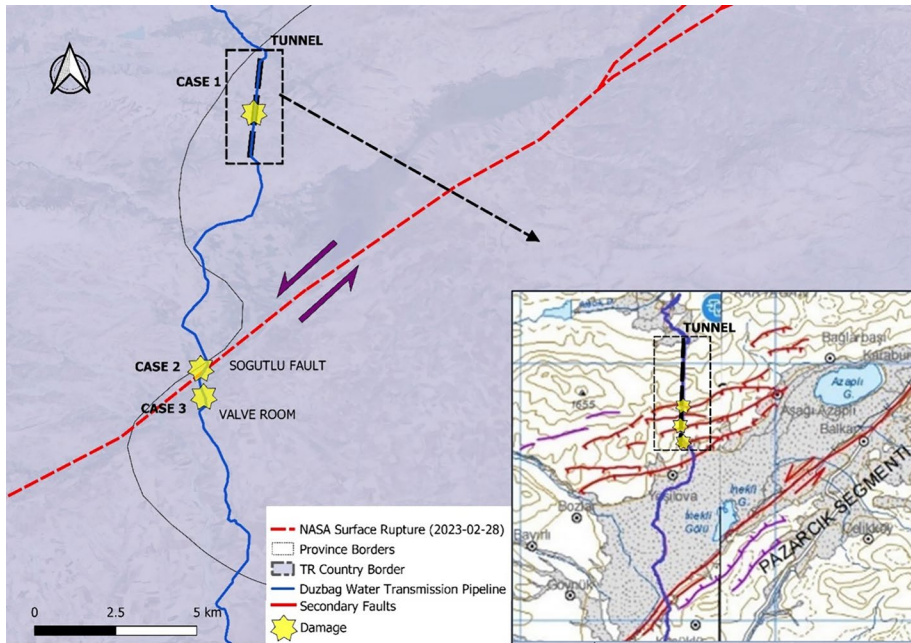


Fig. 11 Damage locations of the Duzbag Tunnel overlaid on secondary normal faults crossing the tunnel axis (background data from MTA (2023))

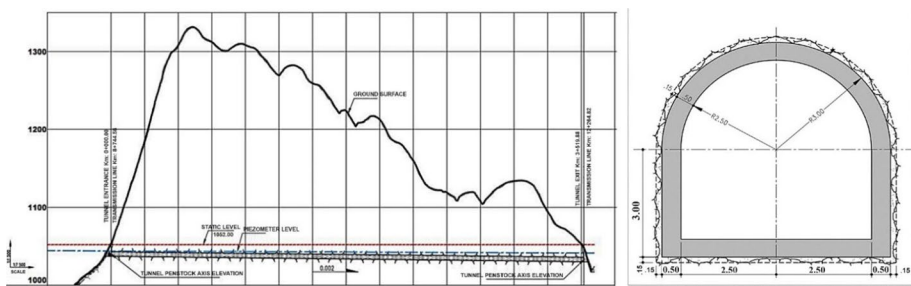


Fig. 12 Soil profile at the tunnel site including the cross sectional view



Fig. 13 The water transmission pipeline inside the tunnel including flexible expansion joints (GASKI 2023)



Fig. 14 Displaced rollers and the damaged lining of the R/C tunnel (See lidar files #SF4 and #SF5)

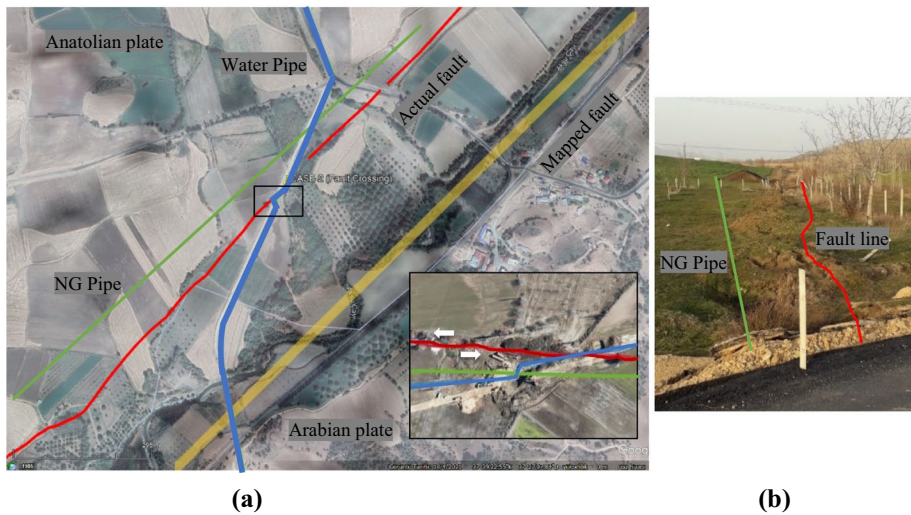


Fig. 15 **a** The fault-pipe crossing, **b** the orientations of the water (blue), NG pipe (green) and fault line (red), **c** the layout of the pipeline with respect to the fault line (K. Maras, Sogutlu)

4.2 Case 2: the Sogutlu fault crossing

The Sogutlu fault crossing can be considered one of the most critical one among all cases mentioned in the previous sections. Figure 15 shows the sketch of pipeline orientations (water and NG) in accordance with the fault line. It was crossing the EAF fault line that ruptured 4.0–5.0 m with an angle of 25 degrees with respect to the pipe axis. Hence the pipeline was subjected to compressive forces due to left lateral slip movement. The NG transmission pipe was also extending parallel to the water pipeline. The pipe was reoriented before the fault crossing by using two pipe bends.

Due to excessive soil deformation (Fig. 16) caused by fault rupture, high compression loads mainly governed the circular cross-sectional shape, resulting in a change in the pipe's geometry to an oval shape (Fig. 17).

The overburden soil has been removed following the earthquake event in order to observe buckles and pipe damages (Fig. 18). According to the initial reconnaissance, there were four major wrinkles reported at the pipe bend which are two wrinkles at pipe bends, one in between these elbows and one another on the other side of the pipe. After



Fig. 16 **a** The fault shear zone of the EAF in Sogutlu, **b** 4.0–5.0 m of fault offset nearby the Sogutlu fault crossing (Courtesy of GASKI)



Fig. 17 **a** Cross sectional distortion and ovalization and **b** wrinkling of the water transmission pipe

the overburden soil had been removed, the pipeline was cut out and replaced by a new one (Fig. 20). Detailed lidar views (Fig. 19) of the damaged sections are also provided.

These damages can be seen in three-dimensional Lidar scans in Fig. 19, which show severe changes in the pipe wall, including wrinkling and ovalization damage states. Lidar measurements have also been made in other studies (Van Ballegooy et al. 2018). The replacement of the pipes took a couple of weeks. However no water shortage happened in Gaziantep as there were two more transmission lines that were operational (Fig. 20).



Fig. 18 **a** Major (wrinkle) and **b** minor (local buckling) damages in the water pipeline (Courtesy of GASKi)



Fig. 19 The 3D Lidar views of the damaged pipe wrinkling (See lidar files #SF6 and #SF7)

4.2.1 Numerical modeling of the pipe-soil-fault system at Sogutlu fault crossing

A three-dimensional numerical model is employed to estimate the response of the pipe-soil system to faulting action. The model consists of soil-pipe interaction algorithm including shell elements (S4R) for the pipe and solid elements (C3DR8) for the surrounding soil. The pipe is subjected to net compressive force due to the orientation of the pipeline. The fault slip deformation was given to the model as quasi-static analysis. The results of the numerical analysis are compared with the observed damage forms. Mohr–Coulomb friction law is employed between the outer surface of the pipe and surrounding soil as in similar literature studies (Banushi et al. 2018; Vazouras et al. 2012, 2010; Kaya et al. 2017).



Fig. 20 Replacement of the damaged sections of the water pipe crossing the NG pipe (Courtesy of Gaski)

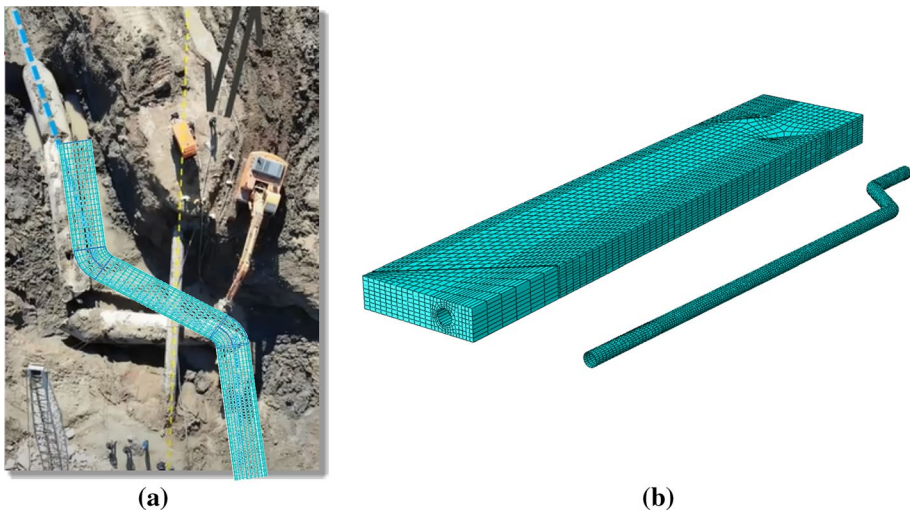


Fig. 21 **a** Rupture of the Gaski–Duzbag water pipe (meshed pipe depicts the original route) **b** soil–pipe (detached) model used for numerical analyses

Pipe operators confirmed that the undeformed water pipe had 70 degrees of pipe angle before it subjected to the fault motion (depicted using meshed finite element model) and then became around 85 degrees due to permanent ground deformation (Fig. 21). Numerical model has also employed with a ST44 steel grade with 14.0 mm of wall thickness as per

field observations whereas stiff soil parameters were adopted as for surrounding soil conditions. The elastic module and cohesion for the surrounding soil conditions are assumed to be $E=16$ MPa and $c=40$ kPa, respectively whereas the poisson's ratio and the density for the soil are taken as $\nu=0.3$ and $\gamma=1.85$ tons/m³, respectively.

Two major wrinkle points (#1 and #2) were observed with a complete pipe wall tears at elbows as well as two minor wrinkles (#3 and #4) without any wall tearing phenomena (Fig. 22). As these buckles formed, the portion of pipe between wrinkles became a mechanism hence, unloaded. As observed from the figure, the axial displacement and rotation demands are accommodated primarily at the two buckles.

4.3 Case 3: the pull-out of the pipe at the valve room (VR#3)

The third case corresponds to the leakage occurring in the valve room. Valve rooms are important support units used to evacuate the air that will occur during filling, emptying and operation of pipelines. They consist of solid concrete blocks partially buried in the ground and contain hydraulic valves to which the inlets and outlets of the pipe are connected. They are usually designed to be partially flexible in order to compensate for axial stresses that may occur due to operational and/or thermal effects. After the earthquake, a pressure drop in the pipeline was detected in the SCADA system by Gaziantep Municipality water systems operators.

The NASA remote sensing data revealed, liquefaction and faulting effects on the downhill side, about 1 km north of the valve room#5. Since those hazards were far from the area, it is more likely that the pull-out action was caused by the landslide action which took place approximately 200.0 m away from the site as shown in Fig. 23.

Field investigations by GASKI revealed leakage at the outlet connection of valve chamber #5 (VR#5), located in an uphill area approximately 1.0–1.5 km south of the fault pipe crossing presented in case #2 (Fig. 23). Data provided by NASA revealed potential landslide zones within 200.0 m of the valve chamber. The 3D views, topography and potential landslide areas are also shown in the same figure.

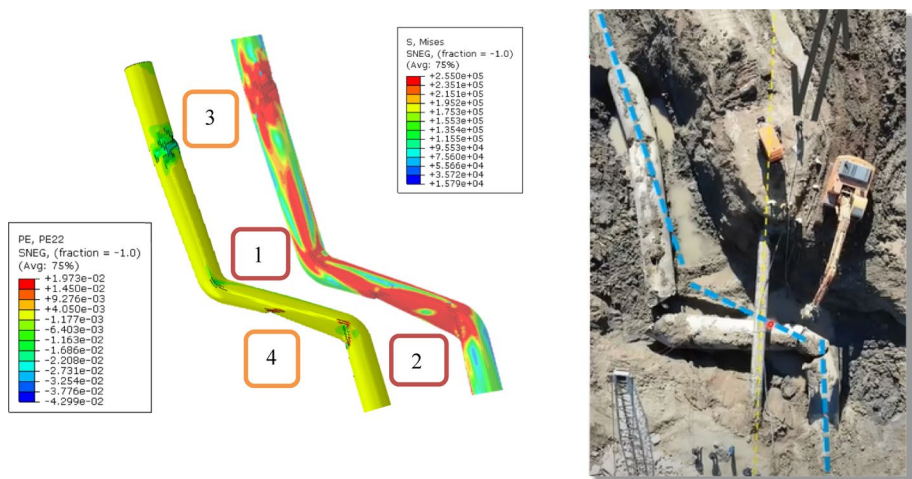


Fig. 22 Rupture of the elbow sections and the nonlinear numerical model results (von-misses and plastic strain) in comparison with the observed damages of the Gaski–Duzbag water pipe line

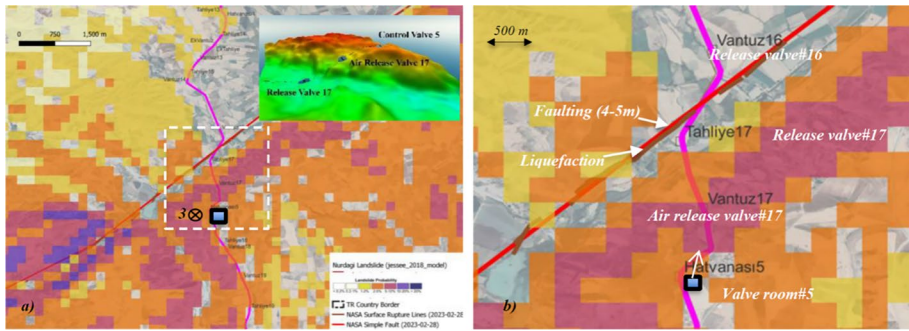


Fig. 23 a Potential land slide zones around b the valve room #5 provided from NASA

Due to relative movement between the pipe inlet and the valve chamber, axial deformations occurred in the pipe. However, the deformation capacity of the pipe-valve connection (pipe removal joint unit) was insufficient to meet the demand. Initially, the stress in the bolted connections was released. However, it was not sufficient to release the excessive tensile force developed in the pipe. Therefore, the GASKI team decided to relieve the elastic stress accumulated in the pipeline by cutting the pipe at a point close to the valve room as

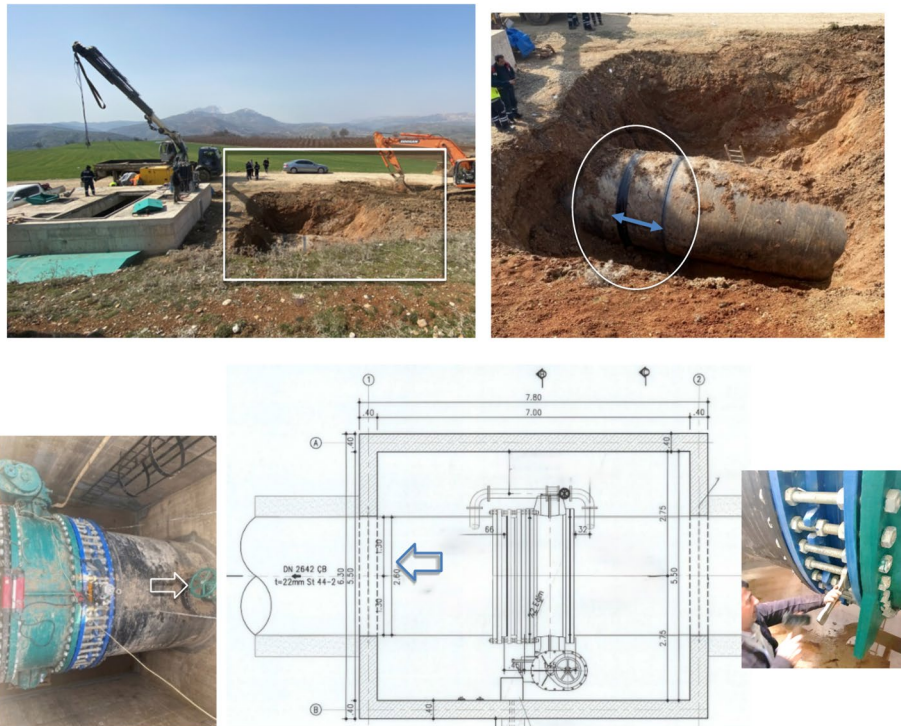


Fig. 24 The pull-out phenomenon at the valve room and replacement (stress releasing) of the pipe followed by cutting and welding process

shown in Fig. 24. After the elastic energy in the pipe was released, a 40.0 cm opening in the axial direction occurred in the pipe. This gap was then filled by welding a piece of pipe as shown in Fig. 24.

5 Conclusion and discussion

The $M_w = 7.8$ K. Maras earthquake caused extensive damage to the pipeline infrastructure. Water and hydrocarbon lines were either severely damaged or ruptured due to PGD caused by FHD. Explosions occurred at two points of the NG transmission line due to surface ruptures causing gas outage in Gaziantep and Hatay. Although the earthquakes had negative effects on pipeline systems, they also provided us with valuable data about the post elastic behavior of the pipes. In this study, first the routes of these pipelines were overlaid on the actual fault lines provided by NASA. After determining the critical points, more detailed studies were carried out to understand the causes of damage.

More specifically the following conclusions were drawn:

1. NG pipelines were crossing EAF line at many points. Major damages experienced at about 18 points mainly due to FDH.
2. Both field surveys and remote sensing data (NASA) revealed that the mapped faults can deviate from the actual fault line. Considering that such uncertainties were quite high in recent earthquakes, FMU is thought to play an important role in the high damage rates observed in steel transmission pipes.
3. The east west oriented CO pipeline was crossing the EAF at a single point, close to the Nurdagi region. No serious damages were reported, and no data was available for fuel oil pipes.
4. The 80 km long (Duzbag–G. antep) water transmission pipeline was damaged at 3 points due to PGDs. Damaged/ruptured parts of the pipeline were repaired and made operational shortly after the earthquake. There were two other functional lines feeding the city. Therefore, the water system remained almost operational, hence water was provided within two days in the city of Gaziantep.
5. The pipeline in the Duzbag tunnel survived the earthquake with minor damages. Flexible joints and rollers moving in the axial direction favorable effects on the response of the pipeline. On the other hand, the tunnel lining sacrificed itself to prevent damage to the inner pipe.
6. The Sogutlu fault crossing was an interesting case study to understand the complex nature of the response of a large diameter pipe with elbow to extreme fault offsets. As a result of 3D nonlinear numerical model analysis, all four damage points observed in the field were able to be predicted.
7. It is particularly important to design smart infrastructures that include integrated systems consisting of SHM and FE modelling of pipeline systems to estimate earthquake damages after the earthquake.
8. In order to increase the resilience of the water systems of mega cities it is important to have alternative transmission lines as in the case of Gaziantep water system.
9. The best way to improve pipe behavior is rerouting. However, this may not always happen due to operational reasons. Another option is to use flexible connections at critical crossings. Such a work is also underway.

10. One option to improve the earthquake safety of existing critical pipeline lines is the development of specially designed bypass or secondary lines to be laid parallel to the existing line. It will be activated in case of failure of the main line and will provide controlled water flow during the repair period of the main line.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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