



### **The Geo-Engineers without Borders Committee**

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The Geoengineers Without Borders Committee of the ISSMGE (GeoWB) has been started in 2022 by President Marc Ballouz at the beginning of his 4 years term in Sydney. He asked Pierre Delage (France) to start and manage the actions of the Committee, with the help of Daniela Pollak, Board member from Chile. This initiative was placed in a context of the beginning of the XXI<sup>st</sup> century, with more and more frequent geo-disasters in conjunction with climate change. Besides earthquakes, that still constitute a significant threat for people and infrastructures, extreme climate events and their consequences in the case of heavy rainfalls, such as floods, landslides and dam failures, cause devastating impacts on communities worldwide.

To foster resilience and prevent the recurrence of such tragedies, it is necessary to address structural issues that may exacerbate the impacts of extreme climate events through planning and adapting infrastructures, based on a relevant risk assessment. This approach requires integrated efforts from experts, governments and communities, combining scientific and technical knowledge, together with social engagement. In this context, the technical and scientific strength of the worldwide ISSMGE network (around 90 countries and 38 Technical Committees) provides a unique tool to serve the human Society.

The aim of the GeoWB Committee is to propose to send volunteer geo-engineers from the ISSMGE network over the world to areas affected by geo-disasters such as earthquakes, landslides, floods, failure of dykes, dam and tailing dams, collapse of geotechnical structures, to mention a few. The GeoWB committee is composed of 19 members from many countries from all ISSMGE regions, including outstanding experts in the various fields concerned, together with Liaison members from Member Societies all over the world. The GeoWB committee made a voluntary commitment to the United Nations Disaster Risk Reduction (UNDRR) office. It has close connections with other similar organisations like ICOLD (International Committee on Large Dams), GEER (Geotechnical Extreme Events Reconnaissance, USA) and RedR-UK (people and skills for disaster relief), and the ISSMGE Technical Committee TC302 on Forensic Engineering.

GeoWB missions are proposed and organised after analysing the local context and expertise in the affected country, utilising where possible local contacts from the ISSMGE network

(Member Societies, Regional Vice-Presidents, members of Technical Committees, and the GeoWorld network). Besides those, our experience demonstrated the fundamental importance of also having reliable personal local contacts.

Great care is devoted to safety and logistical aspects, with all travel expenses supported by the ISSMGE. Geo-engineers prepare afterwards a comprehensive report for national and international authorities. The report includes the following:

- Description and causes of the disaster
- Damages arising from the geo-disaster
- Diagnosis of failures
- Potential remedial measures.

Particular attention is also paid to risk analysis and possible preventive measures for the future, defined in close conjunction with stakeholders and local competences.

Since GeoWB started, their members have been involved in various geo-disasters, with the production of reports that can be found in the GeoWB website (<https://www.issmge.org/committees/geo-engineers-without-borders>) and the ISSMGE Bulletins. In 2026, GeoWB members have been involved in missions in Papua-New Guinea, Libya, Brazil, Bolivia and Myanmar.

To give a flavour of the actions conducted in the first 4 years of GeoWB, this text describes the actions carried out by GeoWB members in geo-disasters resulting in large humanitarian impact such as the Mulitaka landslide in Papua-New Guinea (PNG, with Dr. Jan Kupec through the New Zealand Urban Search and Rescue organisation), the damages due to heavy rains in Rio Grande do Sul, Brazil (with Prof. F. Marinho from Brazil, with the support of ISSMGE), the Derna dams failure (with Eng. A. Chraibi from Morocco, with the support of UNESCO and ICOLD) and the Myanmar earthquake (with Prof. H. Hazarika from Japan, with the support of the Japanese Geotechnical Society).

## The Mulitaka landslide, Papua New Guinea, May 2024

In the Enga Province of Papua New Guinea's Highlands, part of Melanesia, an approximately 650 m long and 150 to 200 m wide landslide occurred on 24 May 2024 at 03:00 local time.



*Figure 1. The Mutilaka landslide in Papua New Guinea (24/5/2024). The landslide is 650 m long. (Photo Dr. Jan Kupec).*

Given the damage to critical infrastructure and the high number of fatalities, the government of Papua New Guinea requested international assistance from experts from New-Zealand and Australia. Their mission was to conduct a geotechnical hazard assessment and provide short-term, medium-term, and long-term options for the recovery of the community. The

reinstatement of the highway connection across the landslide was considered a critical issue, as a community of over 100,000 people was cut off from essential supplies.

Jan Kupec and John Seward were part of the specialist New Zealand Urban Search and Rescue (NZ USAR) team, who worked closely with Australian USAR colleagues, who brought Unmanned Aerial Vehicle (UAV, i.e. drones) capabilities with them, (Kupec & Seward, 2025).

The landslide inundated multiple dwellings, resulting in several hundred fatalities. It is believed to be a rock topple mechanism where toe buckling occurred on very steep bedding, affecting dwellings located near the Highland Highway. Authorities estimate that hundreds of people were living directly below and in the run-out area. The landslide also appears to have triggered multiple rotational and translational landslides, some of which were several hundred metres away from the initial debris run-out area.

Access to the site was challenging due to its remoteness, on-site security issues, and ongoing landslide movement. The fallen debris, combined with the reactivation of adjacent landslides, created a tough operational environment.

Besides a better understanding of the landslide mechanisms, an important geotechnical challenge was to ensure the people safety with respect to other instabilities developing close to the first one. The field team was collaborating closely with geospecialists in New Zealand to provide numerical modelling and hazard maps. This back-office support with further satellite observation was found of great help while on site.

The team proposed a realignment of the roading corridor to avoid an area considered highly susceptible to further landslides, including rainfall triggered slope instability.

## Heavy rains in Rio Grande do Sul, Brazil, May-June 2024

Between end of April and beginning of May 2024, the state of Rio Grande do Sul in Brazil experienced an extreme rainfall event classified as a long-duration extratropical system, with totals exceeding 300 mm in less than a week in several locations, far above the historical average. Persistent and heavy rains were caused by the combined action of a semi-stationary frontal system, a low-level jet stream, and the intensification of moisture transport from the Amazon region (atmospheric rivers).

The intense rainfall triggered widespread flooding, slope failures, landslides, and severe damage to urban and rural infrastructure, especially in areas with steep terrain and poor drainage. The antecedent rainfall led to soil saturation, significantly reducing the infiltration capacity and promoting the development of positive pore-water pressures, which intensified slope instability.

Local contacts were provided to GeoWB by Prof. Gabriela Medero (Heriot-Watt University in Scotland, born in Porto Alegre), which resulted in the mission carried out by Fernando Marinho, who already had some experience in investigating heavy rain geodisasters in Brazil.

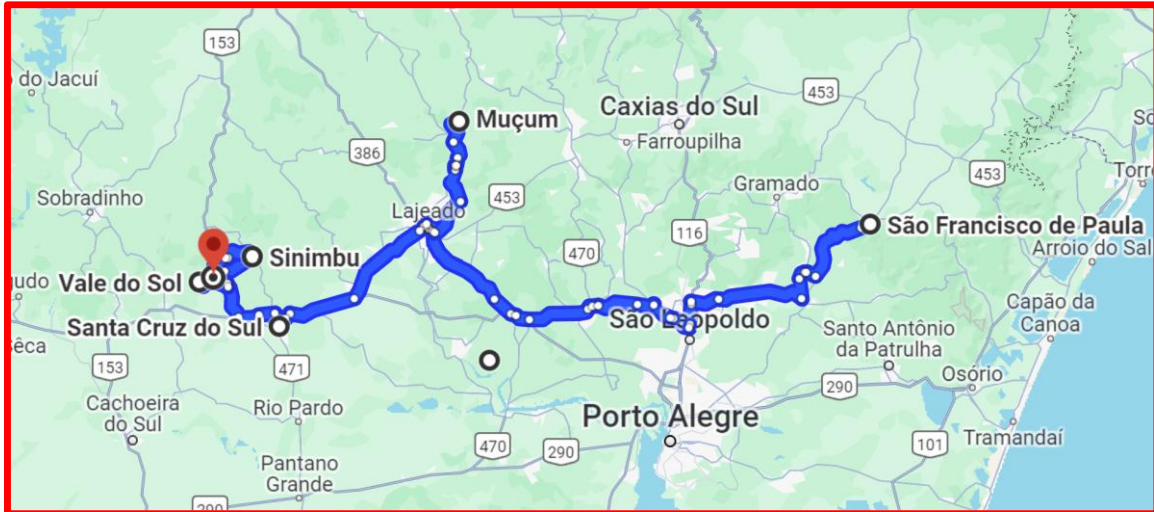


Figure 2. Route of the GeoWB mission in Rio Grande do Sul (June 2024).

Given that the airport of Porto Alegre was neutralised by flood and no longer working, Fernando conducted his mission along a route of 430 km along various damaged locations, starting from a smaller (still working) airport at São Francisco de Paula and going through Muçum, Vale do Sol, Santa Cruz do Sul and Sinimbu (see Figure 2).

The objective was to assess geotechnical risk conditions resulting from the intense rainfalls, focusing on the identification of instability processes, the failure mechanisms, and the proposal of emergency mitigation measures in urban and rural areas. To do so, the methodology adopted was based on an integrated field approach, consisting of on-site visual inspections that enabled the identification of signs of instability. Detailed mapping of cracks, landslides, and erosive processes was carried out, as well as the collection of geographic coordinates for the observed critical points. This information supported a preliminary assessment of failure mechanisms and surface and subsurface drainage conditions, allowing an initial understanding of the factors that contributed to the instability of the analysed slopes. Some illustrative observations made during the mission are now presented.

Figure 3 shows a downslope movement towards the Salto dam reservoir close to Santa Francisco de Paula, with the cracks parallel to the streets observed, the probable wedge failure derived from our observations and the probable direction of sub-superficial flow. A critical issue was to know whether or not it was possible to reopen the school whose classes had been suspended. Together with the Geological Survey of Brazil, we concluded that it was located outside the risky zone and could be reopened.



*Figure 3. Downslope movement toward the Salto Dam Reservoir and nearby school outside the risk area.*

In Santa Cruz do Sul, observations showed that the main cause of the problems lied in pre-existing instabilities that were worsened by rainfall. The entire region has been subject to ground movements for years, and this intense event not only intensified the problem (see Figure 4) but also, in a way, exposed the underlying causes.



*Figure 4. Cracks in streets and instability suggesting large scale ground failure.*

The combination of the following factors created a scenario conducive to infrastructure collapses, threats to community safety, and the urgent need for mitigation actions:

- Rainfall exceeding normal levels,
- Unregulated occupation of slopes,
- Insufficient or non-existent drainage systems, and
- Soils with strength are already mobilized due to saturation.

### **The failure of the Derna dams, Libya**

On September 10-11, 2023, Storm Daniel, after causing important damage in Greece (Garini and Gazetas 2023), moved over the Mediterranean Sea and caused catastrophic flooding in Libya, particularly in Derna, where 10 to 20% of the around 90,000 Derna's population were reported dead and missing, along with 35,000 displaced (Ashoor & Eladawy 2024, see Figure 5). This was due to the collapse of the cascade Abu Mansur (upstream) and Derna (downstream) dams, both along the Derna wadi (dry ravine).

UNESCO, with the support of ICOLD, deployed experts, among which was A. F. Chraibi, to assess the disaster's causes and recommend remedial measures. As direct site inspections were not possible, due to safety reasons, the analysis relied on documents related to dams' design and monitoring provided by local authorities. Meetings with local officials also helped refine the analysis carried out.



Figure 5. Views before and after the devastation due to the floods in Derna, Libya, on September 18, 2023 (Google earth).

As seen in Figure 6 (showing Abu Mansur dam before and after failure), both dams were embankment dams with (too) thin clay core founded on karstic limestone, built in the 70's. They were 73 and 40 m high above foundation for Abu Mansur and Derna, respectively. They had known structural weaknesses, including excessive settlement significant seepage, sometimes conveying dirty water, reported since the 1980s. It appeared that both dams were in such a weak condition that the flood of September 2023 was almost a trigger that led to their failure. Unfortunately, this flood was so massive that the dam failures resulted in a tragedy.

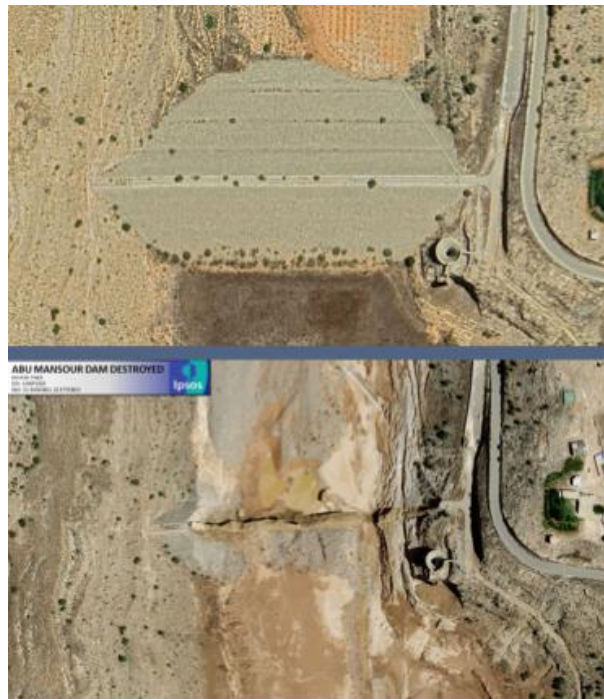


Figure 6. The Abu Mansur embankment dam, before (Google Earth) and after collapse (IPSOS image).

Challenges in estimating rainfall, such as spatial variability and limited reliable data, added uncertainty to determining the event's return period, which ranged from 500 to 5,000 years. Due to poor bedrock conditions, it was recommended that the foundation conditions should be carefully assessed before building new dams upstream of this heavily urbanized area. The

design flood should be reassessed in a conservative approach taking into account the effect of climate change. It is noted that efficient flood protection does not necessarily mean rebuilding storage dams. Any long-term solution should rely on an urban development plan taking into account the right-of-way of the flood control arrangements to be built.

### The 2025 Myanmar earthquake

On March 28, 2025, at 12:50 MMT, a Mw 7.7 earthquake struck near Mandalay, Myanmar, along the Sagaing Fault (one of Southeast Asia’s most seismically active fault systems) at a shallow depth of 10 km (see Figure 7, that also shows strong earthquakes occurred since 1929). This earthquake was one of the largest to hit the region in decades and caused widespread destruction across central Myanmar. Its impacts extended beyond Myanmar’s borders, with shaking felt in neighbouring countries as well, including in Bangkok, 1000 km away. The scale of damage to infrastructures, buildings, and cultural heritage sites underscored the seismic vulnerability of the country.

A reconnaissance mission was organized from June 13 to 16, 2025 by the Japanese Geotechnical Society (JGS) under the leadership of Prof. Hemanta Hazarika (Kyushu University, Japan), with the local support of the Myanmar Geosciences Society (MGS), the Federation of Myanmar Engineering Societies (MES) and several international partners.

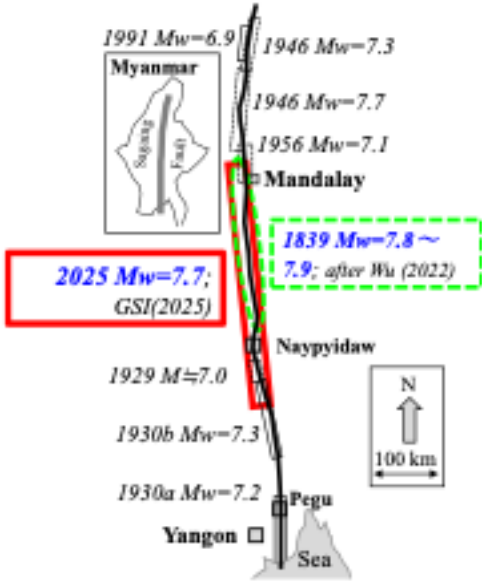


Figure 7. Historical earthquakes caused by Sagaing fault (Modified from Soe and Watkinson, 2011 and Wang et al., 2014).

The earthquake severely impacted Myanmar’s transportation network, especially the Yangon–Mandalay Highway. Extensive liquefaction-induced settlement led to uneven road surfaces and distorted alignment. The photo in Figure 8a shows bridge abutment damaged due to lateral spreading of soils, resulting in severe structural failure. Liquefaction damage with sand boils were also observed in an under-construction site of shopping mall in Mandalay (Figure 8b) and widespread in a village close to Naypyidaw, the capital of Myanmar. In this area, low converted N value based on dynamic cone penetration tests and a shallow groundwater table approximately 1.2 meters below the ground surface confirmed high susceptibility to liquefaction.



a) b)

Figure 8. a) Abutment damage along the Yangon – Mandalay highway ; b) sand boils at shopping mall site, Mandalay.

In various buildings in which ground floors consisted of columns with very few shear walls (Figure 9a), it was observed that lower stories completely crushed, whereas upper floors resisted better. This highlighted a fundamental design deficiency that must be urgently addressed in future seismic design codes and retrofitting programs, particularly for reinforced concrete buildings in high-risk areas.

In some places, the fault could directly be observed at surface, like in Naypyidaw where the observed ground motion intensity was high. Figure 9b shows a significant right-lateral displacement accompanied by shear deformation of the ground surface in the Children’s Specialized Hospital. Buildings situated directly atop the fault rupture that sustained severe damage, whereas a room located about ten meters away from the rupture suffered much less damage. This confirmed that, in this area, the primary cause of fault-induced damage was surface deformation rather than ground shaking.

Devastating losses to Myanmar’s rich cultural heritage (temples, pagodas, historic buildings) were also observed, raising the fundamental question of whether to prioritize authentic restoration using original materials or to focus on rapid recovery using modern method.



a) b)

Figure 9. a) Sky Villa condominium in Mandalay (207 fatalities); b) Children’s Specialized Hospital in Naypyidaw.

The 2025 Myanmar Earthquake caused a wide spectrum of damage, including liquefaction-induced failures, slope failures, building collapse, and cultural heritage destruction. The reconnaissance survey confirmed that Myanmar’s infrastructure and building stock remain highly vulnerable to strong earthquakes. Moving forward, Myanmar must prioritize:

- Strengthening foundations and embankments against liquefaction,

- Retrofitting vulnerable soft-storey structures,
- Expanding seismic monitoring networks,
- Developing regional hazard assessments that incorporate long-period seismic impacts.

This reconnaissance also provided critical lessons for seismic risk management throughout Southeast Asia, based on which academia, governments and industries can collectively take measures to reduce future losses and build greater resilience against major earthquakes.

## Concluding remarks

The examples of GeoWB missions on geo-disasters demonstrates how a structured, volunteer-based mobilisation of geotechnical engineers can, within a reasonable cost, complement emergency response and support recovery and enhancing resilience, capitalising on the ISSMGE network and its commitment to UNDRR.

Across the four case studies presented, GeoWB actions illustrate several transferable contributions to soil mechanics and geotechnical engineering practice:

- The need to ensure safe working conditions for missions. This was particularly critical in Papua New Guinea and Libya due to general unsafe – if not dangerous – societal conditions, and safety was ensured with the support of armies, including to go in remote locations (helicopters, four-wheels cars...). Note that this was not the case in the central plain of Myanmar.
- Rapid, defensible risk screening for recovery decisions. In Papua New Guinea and Rio Grande do Sul, the mission combined field reconnaissance, mapping of cracks and slope processes, and preliminary mechanism assessment to support emergency mitigation and decision-making; a concrete example in Rio Grande do Sul was the assessment (jointly with the Geological Survey of Brazil) that enabled reopening a school after confirming it laid outside the risk zone. A similar process was followed in Papua New Guinea to know where it was possible to safely relocate displaced people. In all cases, local authorities, institutions and people were really very grateful with mission teams.
- Integration of field and remote technical capabilities under constrained access. In Papua New Guinea, the hazard assessment benefited from UAV-enabled reconnaissance and “back-office” numerical modelling, hazard mapping, and satellite support, improving situational awareness in a challenging operational environment.
- Forensic-style diagnosis and prevention-oriented recommendations, as done in Myanmar. In Derna, where direct inspections were not feasible, expert assessment based on design and monitoring documentation supported causal interpretation and remedial recommendations, including conservative reassessment of design floods under climate change and careful appraisal of foundations prior to any rebuilding.

Finally, the GeoWB operational model contributes to the profession by formalising how geotechnical volunteer missions can be organised safely and effectively, producing, for reasonable cost, comprehensive reports that document causes, damages, diagnoses, remedial options, and preventive measures for authorities and stakeholders. Looking forward, the strongest impact of GeoWB actions will come from continuing to standardise mission workflows and strengthening interfaces with local institutions, so that post-event reconnaissance and engineering judgement translate consistently into actionable recovery priorities and sustained risk reduction. This translation crucially depends on coordinated engagement with affected communities, local competences, public authorities and private stakeholders, supported by professional organisations that can mobilise qualified expertise, provide ethical and technical guidance, and facilitate the timely exchange of data and responsibilities across response, recovery, and prevention.

Another action asked for by people in risky or geo-disasters affected areas is that of proposing local workshops to familiarise stakeholders, local authorities and geo-engineers to improve risk assessment and prepare local people to face possible geo-disasters through appropriate workshops in presence. This has been done with the Municipality of Bogota in Bolivia in May 2024 (Prof. F. Marinho, GeoWB member with Prof. B. Caicedo from Colombia) and is in discussion with the Philippines Member Society, following the earthquake and rain-induced landslides occurred in September 2025. Perspectives also exist in South America, where the degradation of tropical soils and the resulting sensitivity to heavy rainfalls and the induced landslides is a widespread problem.

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