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Mitigation of Physical Risks on Tracks, Cycle Paths and Pedestrian Sidewalks, Caused by Falling of Boulders, Gravel, Sand, Silt and Clay from the Scarp and Crown of the Miraflores Malecon – Lima

Tomás Ezequiel Gallarday Bocanegra, Ciro Sergio Bedia Guillen, José Ronald Vásquez Sánchez, Luis Francisco Díaz Padilla, Cleto Mauricio Vidal López
Universidad Nacional Mayor de San Marcos, Perú

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Abstract:
This work was carried out in the Miraflores district, in which we studied an old sector of the alluvial fan of the Rímac River, which belongs to the area of interest, which is the sea cliffs. That, verified in situ, there are clayey, silty, sandy and pebble horizons with different granulometry, which have different bearing capacity indices up to 8kg/cm2, when collecting data with the Prima 100, is similar to the resistance of the soil in the Historic Center of Lima; which in the XIX - XX centuries were good aquifers.

In Miraflores the growth of their houses is vertical and their population located in them requires more and more water, which is obtained by pumping aquifers with lenticular geometry in series from surface to depth, a fact that originated the decrease in the piezometric level, evidenced in the marine escarpments of its cliff, where travertines are present in crusts and leachate spills that are visible.

The present project was concluded in which we indicated the causes that originate the falls of rocks from the cliff, to achieve this we mapped and determined the areas of greatest erosion, caused by marine dynamics, added the calculations with the values obtained in UNI laboratories

– UNMSM, result of the in situ sampling where the PRIMA 100 was used, reinforced by the analysis of the IGP seismic wave train plans. Googleearth, Googleearth-pro, Googlemaps, in the end we produced this report where we proposed rules to mitigate risks and prevent future loss of human life.

Keywords-Stability of the sea cliffs, Miraflores district, Mitigation of physical risks, Miraflores boardwalk, landslides with liquefaction of clays and silts, solifluxion of the sands, Miraflores boardwa

Background of the Study
Until 1746, human settlements in the Miraflores district were far from the sea cliffs, and at the same time the free areas were used as dumps and rubbish dumps, the escarpment is marked by the drainage of old torrents as well as others that already existed in the cliff that extends from Chorrillos to La Punta, now they are the cliffs of the districts of La Perla, San Miquel, Maranga, San Isidro, Miraflores, Barranco and Chorrillos, access to marine beaches was made through the drainages or steeper slopes, at that time in which the sea reached the base of the escarpment of the cliff, 1875 the Regatas Lima club was created, which built its first breakwaters with andesitic rocks of 50 and 100 meters in length, 1881 the Chilean and Peruvian army moved through its crown of sea cliffs,The people dedicated to artisanal fishing do the same, she traveled from Chorrillos to La Punta, with the districtization process her irregular urban invasion began. In 1940 an earthquake occurred that cut part of the crown of the boardwalk, causing the verticality of its escarpments. In the year 1943 the Leoncio Prado Military College was founded, in the 1960s the French built the sea breakwaters in the shape of the letter T, for this they use andesitic rocks and the Regatas Lima club continues to gain more land from the sea using dacitic andesitic rocks thus originating the current beaches. In 1940, an earthquake occurred that cut part of the crown of the boardwalk, causing the verticality of its escarpments. In 1943, the Leoncio Prado Military College was founded. In the 1960s, the French built letter-shaped marine breakwaters. T, for this they use andesitic rocks and the

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This work considered the beaches between the Salto El Fraile breakwater and La Punta, taking relevance the escarpment and the crown of the Miraflores district boardwalk, its crown has an average width of 50 meters, its historical past shows that it is not vulnerable to tsunamis but if it is earthquakes, they caused rockfalls, there were May 31, 1970,10-17-1966, 10-03-1974, 08-16-2006, 08-07-2007, the landslide occurred on 08 -11- 2020, caused vehicular interruptionpersonal accidents and property damage, this work gives scope through regulations to mitigate it and avoid loss of human life.

Justification

This project that developed in situ data collection, soil, water and air in different places and dates at the crown and base of the Miraflores district boardwalk, with the quantitative values we elaborated a data, which, analyzed in detail, allowed us to generate Norms to mitigate physical risks, in vehicular roads, cycle lanes and pedestrian paths, to avoid future material accidents, personal with probabilities given by fatalities or loss of human life, its justification was given in two ways:

Practice

In it we include all the works that were carried out in situ, mapping, measurements with the PRIMA 100, sampling, etc. The development of this project seeks to remodel the public space of Miraflores at the crown of its boardwalk,In order to recover both the public space of its currentcrown and that of part of the roads integrating both areas, the Manuel Bonilla stadium will be built in its western sector crown, next to the Museum of the Memory of the Martyrs of Terrorism, adding value to the place, by giving it a new identity in the city of Miraflores, becoming a central square that will lower the risks that landslides occur because it is a terrace in favor of gravity.

Theoretical

The data collected with the PRIMA 100, IGP seismic map, mapping of the isobaths and Googleearth images, as well as the CONIDA PERUSat-1 satellite, photos taken with drones, the excavations carried out in the crown and escarpment of the Miraflores boardwalk, with use of andesitic rocks in moles or tiles such as:

Terraces built in the Bajada de la quebrada Armendáris, terrace excavation where the Larco Mark shopping center was built,
excavation of terraces to build the Parque del Amor, excavation of terraces to build the Museum to the Memory of the Martyrs for Terrorism, excavation of terraces to build on them the Manuel Bonilla Stadium which, according to the projections of the commune, the works in the area they would be starting between the months of February and March of this year and would have an execution period of approximately 11 months. We will send a copy of this report to the local authorities, explaining to the mayor and his population about the mitigation of these risks.

Contribution And Impact

It was an emerging priority and important to carry out this study considering that it seeks to mitigate the risks to avoid fatal personal accidents and loss of human life, leaving disasters or material losses in the background, in addition the quantitative data is evidenced in the statistics of the LOS DELFINES Salvage Center, which in summer and other seasons, is as follows:

Year 2019 Rescue tracks 07, rescues from the sea 1320, drowning 07, missing 02, discovery of corpse 05.

Year 2020 Rescue tracks 04, rescues from the sea 1088, drowning 09, missing 03, discovery of corpse 14.

The works carried out in the excavation of terraces in the crown of the Miraflores boardwalk as from West to East Museum to the Memory of the martyrs of terrorism, Maria Reiche park, Miraflores Chinese park, area surrounding the Marina lighthouse, love park, excavations in areas surrounding the suicidal bridge over Malecon Balta, has lowered the risks for landslides and rockfalls to occur. This is explained in this work to the district authorities of Miraflores, so that they influence citizen participation, thus mitigating the risks in the use of roads, cycle paths, bridges and sidewalks near the beaches of the green coast, signaling with bright and phosphorescent colors, in the of indicative signs that will be located in areas or places
visible, in addition, security guards must be placed at the crown of the boardwalk to prevent people from falling and suicides.

Hypothesis

General

The physical risks due to falling rocks from the escarpments of and from the crown of the boardwalk in the district of Miraflores, which impact on vehicular roads, cycle paths, bridges and pedestrian paths, can be mitigated.

Specify

The technical works carried out in situ will be the basis for proposing to mitigate the physical risks due to rockfalls from the escarpments and the crown on the Miraflores district boardwalk.
When this proposal was prepared, for the neighborhood president and also for the authorities of the Miraflores district, it alerted and aroused their interest to mitigate the presence of physical risks, avoiding personal accidents that lead to the loss of human lives.

GOALS

General

Study the mitigation of physical risks on tracks, cycle paths and pedestrian paths, caused by the fall of boulders, gravel, sand, silt and clay from the escarpment and crown of the Miraflores- Lima boardwalk.

SPECIFIC

Determine through technical sampling, the resistance of the soil, its permeability and the amount of water that percolates in it, thus knowing its bearing resistance. Apply STANDARD E-50, to know the risk of high-rise civil works adjacent to the boardwalk

Work Methodology

After reviewing vast written bibliography on the Miraflores boardwalk, with the work group we carried out on-site inspections, visits to the entire Costa Verde to the crown of the boardwalk from Chorrillos to La Punta, verifying that the highest height, 50 to 60 meters of its escarpment, was located in the sections of the Chorrillos, Barranco, Miraflores and San Isidro districts, we verified that the highest height is in the boardwalk of the Miraflores district, which includes the width of its crown excavated in several sections, it was controversial to agree on the ideas that go into this report, which were born from detailed, meticulous observations made in the visible geological sectors of the work area, it was thus that it was considered to use the numerical scales 1/500 and 1/5000. We indicate that its crown of the boardwalk is masked by vegetation such as grasses, bluebells crassula sp,

The beach line at its base was inspected with the work team that is part of the ALBUMIS research group, to verify the sectors of landslides and rock falls identified on the boardwalk of the Miraflores district, a landslide located in the ascent lane of the Armendáriz viaduct, has a starting height of 25 m, the break is irregular and discontinuous. It caused the breach of the security mesh and affected.

The pedestrian and vehicular route in a stretch of 22 m, caused the temporary closure of both lanes. At the time of the inspection, cleaning and reconditioning work was being carried out, for the normalization of traffic, falling rocks, it presents an arch height of 22 meters, no great damage was caused by wear of the polyethylene mesh. With googleearth pro, measurements of the crown were made, giving areas of: 626258.63 m2 and a perimeter of 9613.96 ml. And the beach length approximately 4900.00 ml protected by five breakwaters armored by andesitic rocks [cap. Googleearth screen.

The UNMSM with this report meets one of its goals of giving support to the community and local governments. Reliable, timely and accessible in geology. The cliff and the crown of the Miraflores district boardwalk present risks, vulnerable sectors, geological hazards due to landslides and rock falls. The earthquake registered on June 22, 2021, whose epicenter was 32 km SW of the Mala district, Cañete region, with a magnitude of 6.0 (IGP), triggered the fall of materials of alluvial origin and anthropic solid waste from landfill that temporarily blocked the Malecón Grau and Bajada de Armendáriz roads. Among the conditioning factors that caused landslides and rockfalls are: Excessive use of water, escarpment close to 90°, and heterogeneous soil material.

Geology Of the Alluvial Delta Of Lima

The Rímac River begins at 3,400 meters above sea level by the union of the Blanco River with the Yauliyaco River, which is born in Ticlio, at 4,820 meters above sea level, and the Blanco River is born by the melting of the snowy Tatajaico at 5,000 meters above sea level. On its way, the Rímac River, before Chosica, receives the waters of the Santa Eulalia River in its downstream right sector. The Rímac river has a larger river basin than the Chillón and Lurín rivers. This account is sparsely vegetated in its
slopes, which favors greater soil erosion, a phenomenon caused by rainfall.

It is thought that the chronology of the fluvial fan of the Rímac river valley is close to 1,500,000 years. It is evident that the three rivers that contributed their eroded sediments of their journey (Rímac, Chillón and Lurín), were complete, being deposited in their Lima ejection fan, which has tens of cubic kilometers.

The eroded materials along the Rímac River and its tributaries are located in fluvial terraces, floodplains and slopes that give U-shaped transversal profiles. Glacier valley above 4000 masl, and V-shaped, in its middle course. Its passage runs over geological faults that originate canyons such as the Infiernillo San Mateo, the same also happens in the Blanco river and Millotingo river.

In the external geodynamics originated in the trajectory of the Rímac river, influences erosion processes, landslides, landslides, landslides, mass movements, soil creep, telluric movements, rockfalls due to temperature changes (day, night) and Anthropic action, the supply of fresh water to the aquifers formed in its ejection cone located at a level between 10 to 1000 meters above sea level. the tributary rivers of the Rímac, the Santa Eulalia river and others of lesser flow.

. The Rímac River and its tributaries receive washing or leaching from solid waste dumps and tailings from exploited or currently exploited mines located within its basin, due to fluvial, wind and gravity erosion, despite the fact that many of These tailings have geomembranes as time goes by, destroying them. These mining sites are the following:

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Rimac river basin

Barmine and Perubar Mine abandoned, El Barón mine depleted, El Farallón mine closed, Tamboraque mine in operation, Casapalca mine in operation, La Volcan Mines closed, Millotingo mine depleted, Pacococha mine depleted, Huampar mine depleted, Condor Pasa mine depleted,
depleted Pariamina mine, depleted Colqui mine, depleted Aurelio mine and Venturosa mine among other small ones.

Chillón river basin, closed Huamantanga mine, complex of small mines on its tributary Seco river, closed Canta Gallo mine and Culluhuay gypsum quarry.

Lurín river basin, Las Palmas mine closed.

These mining tailings and dump effluents contaminate the surface waters of the Rímac River and the groundwater located within the alluvial cone of Lima, which is made up of rocky material eroded from Paleogene-Neogene volcanic sedimentary and igneous rocks and mid-Cretaceous calcareous rocks. In the upper and Triassic-Jurassic period, the erosion process was favored by the geological faults that raised these limestone blocks. Granitic igneous rocks that are members of the coastal baotolith were also eroded, contributing their sediments to the dejection cone of the Rímac, Chillón and Lurin rivers, a part of its thickness is visible in the valley located between Morro Solar and La Punta. It is thought that when the fan of Lima was in the process of formation, the Rímac River did not have a fixed bed, That of its course constantly changed in different phases from Chorrillos to La Perla until it found its current cause, evidenced by the powerful horizons of limes and clays in Malecón Grau and Paímac, Chillón and Lurin Ate de Barranco. When describing the boulders of the Rímac River, it is verified that they are igneous rocks of the granite, andesite and limestone type.

The groundwater present in the conglomerate horizons of Lima, is supplied by the liquid element by percolation and expansiveness of its waters, its eleven million of its population satisfy their water needs. The interesting thing about these waters is that it supplies the underground water formed by all of them, the surface of its soil has been populated even in the outcrop of rocky massifs such as hills located in La Molina, hills of Ate, Huachipa, El Agustino, Cerro San Cristobal, hills of UNI, Comas, Carabayllo and Ventanilla, this has increased its population with the location of houses on the edges and

on top of these hills of intrusive rocks and compact sedimentary rocks. The set of these houses is made up of multiple human settlements that require more and more water, a large volume is obtained by pumping groundwater, which is then stored in aerial (Abyssinian) or static tanks located at a higher level than the human settlements, achieving so its fluides by gravity. The additional places produced by the upwelling of groundwater must be considered, zapan is another, it is not the lagoon of La Molina, which, in the past, was a quarry from which construction materials for houses were extracted in colonial times and early of the 20th century of the Republican era. Its exploitation was halted when the quarry reached the groundwater table of the groundwater supplied by the expansion of the Rímac River.

Another place of outcropping of groundwater from the Rímac river is the Pantanos de Villa. The fresh water present there is fed by groundwater from Lima, which migrates through fractures or faults in the compact rocks located to its NE. The floor of the Rimac River's alley is an open aquifer on its periphery and is not confined.

This receives water from the water table and reaches its rocky basement of compact sedimentary rocks and volcanic rocks from the lower to middle Cretaceous. The water table is higher near the Rímac river and the river bed is at a depth of 10 to 20 meters from the surface of its fluvial terraces. The greater the distance from the river, the lower the water table is with respect to sea level. That is, it is found at a greater depth than the upper surface of the ejection cone and reaches its depths (from 70 to 220 meters). In 1951, on the cliff in front of the Agua Dulce beach, in Chorrillos, 15 meters above sea level, curtains of freshwater springs emerged that fell in little mussels that corresponded to the drainage of Lima's groundwater. Currently, We do not see these jets of water on the floor cliff of the ejection cone, due to excess pumping in the area of the cone, Chorrrillos, Barranco and Miraflores. Currently, we see vestiges of the upper level of the levelwater table of the past on some cliff edges where they have not been cut to extend the Costa Verde area. Surface that has an irregular layer of travertines that is the zarro of the leaching of the calcareous rocks given in the geological past, where the subterranean waters dissolved fine particles of calcium carbonate (calcite) of the soil of the ejection cone of the Rímac river (soil de Lima) and, when they surfaced on the cliff, they deposited their solutions layer upon layer, forming the travertines. Its upper footprint is 40 meters above sea level, approximately halfway up the cliff. Today, the outcrop of groundwater from the Rímac River can be seen in various sectors of the Costa Verde at level 0, similar to that of the sea. Said water table has dropped 40 meters, due to excessive pumping of

groundwater in the Miraflores district. In another way, on the marine terrace of the Costa Verde next to the Regatas club, the groundwater of the Rímac river's ejection cone is at sea level. This is thought to lie above marine groundwater due to its lower specific gravity.

Conclusions

The physical risks due to rockfalls and landslides at the crown of the boardwalk in the Miraflores district between the museum to the memory of the martyrs of terrorism and the Armendaris avenue have already been partially mitigated by the works carried out on its crown, by l, The local authorities at the time such as:

Museum to the memory of the martyrs for terrorism, Bonilla stadium, Maria Reiche park, Chino park, the surroundings of the Marina lighthouse, Love park, the Balta descent, Larco Mark and the Armendaris descent, with the elaboration of terraces, i civil fibers, with construction of slabs or footings and three or four basements of the works located in the northern sector of the malecóin crown.

The technical work carried out in situ by the authorities has been masked by plants such as Crassula sp. Campanilla, American gras or, palm trees, cockatoos and cactaceous plants, sabila, tangles and coastal molles, the escarpments have been protected by polyethylene mesh and at the base
They have Installed Eucalyptus Trees That Make Good Use Of Fresh Water, Thus Reducing Physical Risks Due To Its Mitigation On Tracks, Cycle Paths And Pedestrian Sidewalks, Caused By Falling Of Boulders, Gravel, Sand, Silt And Clay Of The Scarp And Crown Of The Malecón Miraflores .

The green embellishment of the crown of the Miraflores boardwalk demands the use of a lot of fresh water, which is pumped from its underground aquifers, thus generating its recycling, when it exceeds the absorption of the soil or humic fringe, its supersaturation and therefore its liquefaction occurs of clays and silts, a physical process that contributes to the occurrence of sporadic landslides and rock falls due to seismic movements, otherwise the escarpment and the crown of the Miraflores boardwalk are stable and the risks for personal or material accidents are minimal in accordance with the E-50 Standard.

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