

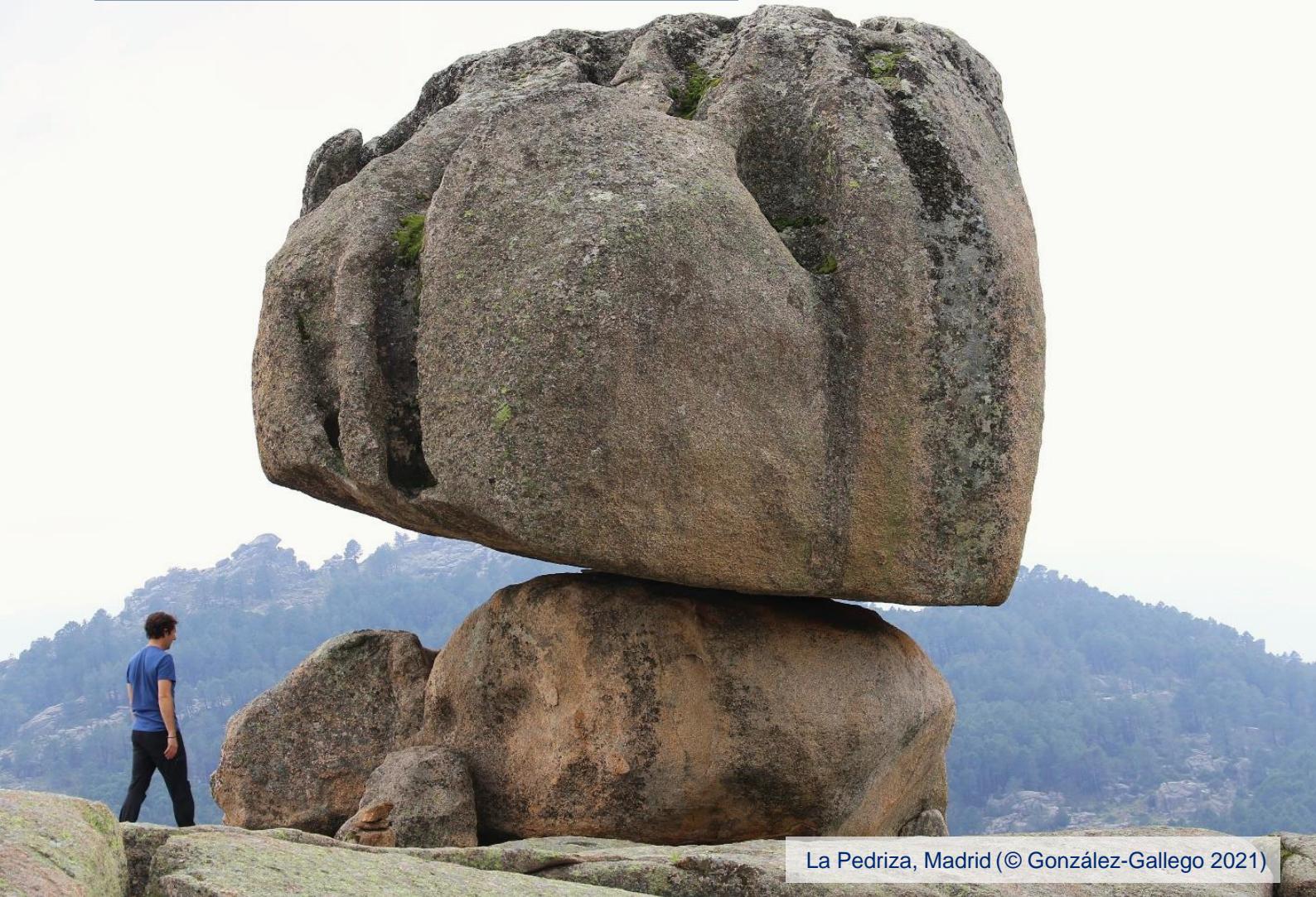


SOCIEDAD ESPAÑOLA DE MECÁNICA DE ROCAS

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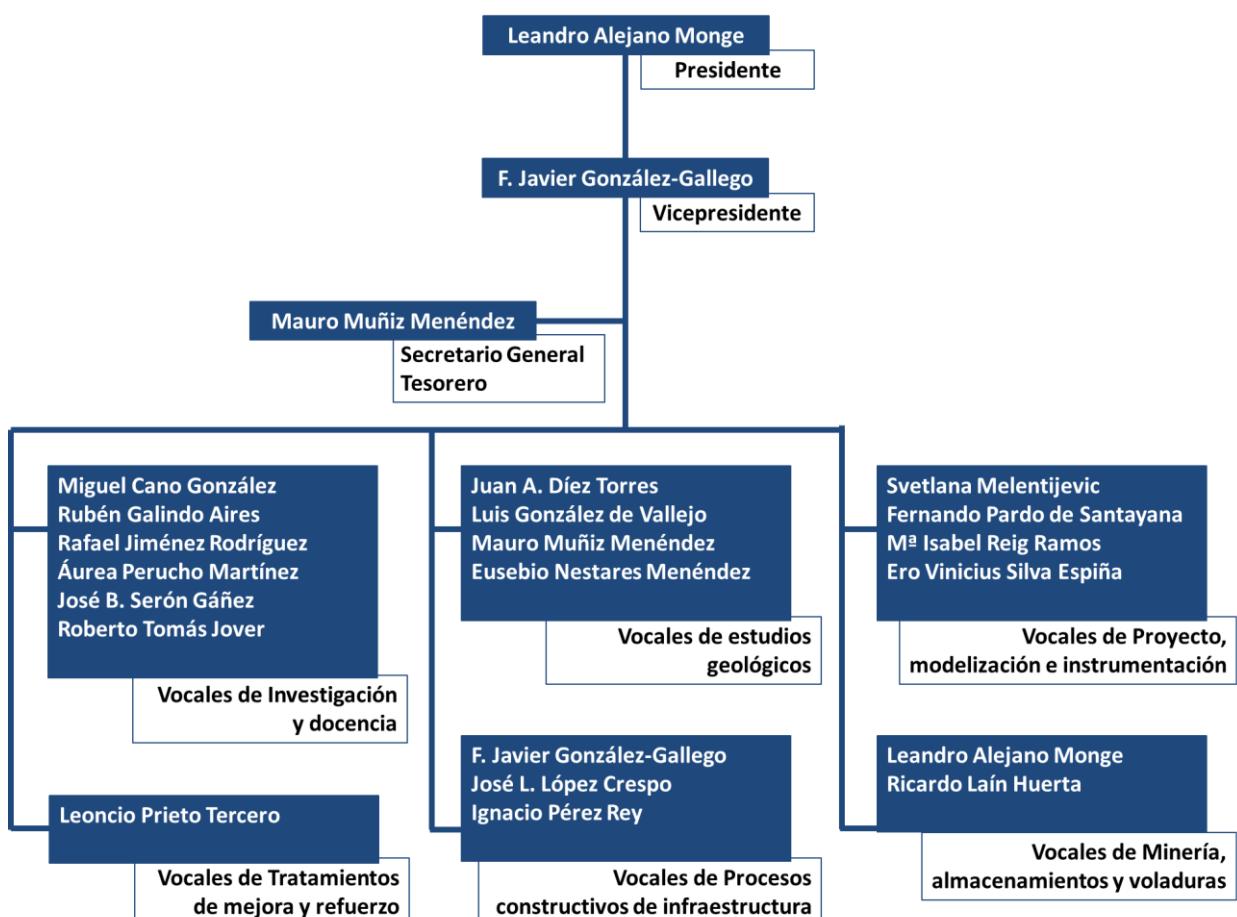
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Editorial

ÉPOCA DE CAMBIOS, CAMBIO DE ÉPOCA

La inesperada aparición del Covid-19 en 2020 ha cambiado significativamente nuestras vidas. Su devastador impacto afectó a toda nuestra sociedad, a la economía, a la ingeniería, a la cultura, a la ecología, a la política y prácticamente a todos los aspectos de nuestra forma de vida. Nuestras actividades laborales tuvieron que adaptarse a los nuevos requisitos de distanciamiento social, por lo que no nos quedó más remedio que transitar vertiginosamente hacia nuevas formas de trabajo y de relación con los demás.

La SEMR se vio obviamente afectada por estos eventos. Hubo tiempo para celebrar el 30 de enero de 2020 en Alicante una exitosa Jornada Técnica Extraordinaria con el título “Riesgos geológicos en la mecánica de rocas: Interacción con las infraestructuras”. A partir de ahí, la jornada anual, punto de encuentro de nuestros socios, tuvo que ser suspendida. Las reuniones de la Junta directiva tuvieron lugar de manera telemática.

La Sociedad Internacional de Mecánica de Rocas (ISRM), se vio si cabe más afectada por la pandemia. La mayoría de sus actividades se basan en contactos personales. En consecuencia, muchas de las actividades planificadas tuvieron que posponerse, cancelarse o realizarse telemáticamente. En particular el congreso internacional de la ISRM planificado para tener lugar en Trondheim, Noruega, tuvo que ser pospuesto primero y luego cancelado. Sin embargo, un nuevo impulso se está desarrollando para incrementar el número de cursos, conferencias y actividades on-line que abre además las puertas a los menos favorecidos.

La velocidad imprevista de la propagación del virus nos obligó a afrontar una situación sin precedentes. Aún se esperan tiempos difíciles, pero es posible mirar hacia adelante con optimismo y nuevas oportunidades se abren ante nosotros. Las habilidades que todos hemos ido desarrollando, los jóvenes con especial eficacia, para trabajar de forma remota nos permitirán, sin duda, recuperar rápidamente el impulso, e incluso extender el abanico de actividades de la SEMR.

Algunas de las nuevas formas de trabajo y relación adquiridas probablemente persistirán, aunque no sé cómo y hasta qué punto seguirán formando parte de nuestras vidas en el futuro. Presiento que el mundo ha cambiado de forma definitiva. En todo caso, y en la medida que contribuyan a fomentar y diseminar el conocimiento y la aplicación de la mecánica de rocas, objetivo último de nuestra sociedad, bienvenidas sean. Seguiremos siendo capaces de adaptarnos.

Leandro Alejano
Presidente SEMR

Nuevos Estatutos

El día 27 de febrero de 2020 la Asamblea General de la Sociedad aprobó los nuevos estatutos que regirán el funcionamiento de la SEMR a partir de ahora.

El nuevo texto, propuesto por la Junta Directiva, recoge todos los cambios necesarios para cumplir con las modificaciones legales acaecidas desde la redacción del texto anterior, y permite a la SEMR cumplir con todos los requisitos establecidos por la Ley Orgánica 1/2002, de 22 de marzo, reguladora del Derecho de Asociación.



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ESTATUTOS

CAPÍTULO I. DISPOSICIONES GENERALES

Artículo 1. Denominación.
La Sociedad Española de Mecánica de Rocas (SEMR) es una asociación fundada en el año 1927, con personalidad jurídica y plena capacidad de obrar, careciendo de ánimo de lucro.

Se rige por los presentes estatutos al amparo de la Ley Orgánica 1/2002, de 22 de marzo, reguladora del Derecho de Asociación, y normas complementarias. En todo cuanto no esté previsto en los presentes Estatutos se aplica la citada Ley Orgánica 1/2002, de 22 de marzo, y las disposiciones complementarias de desarrollo.

Artículo 2. Duración.
Esta Asociación se constituye por tiempo indefinido.

Artículo 3. Fines.
La Asociación tiene como fines: promover la colaboración entre la comunidad técnica y científica interesada en el campo de la Mecánica de Rocas.

Artículo 4. Actividades.
Para el cumplimiento de estos fines se realizan las siguientes actividades:

- a) Organización de cursos, conferencias, coloquios y reuniones.
- b) Publicaciones e intercambio de documentación científica y técnica.
- c) Colaboración con grupos y asociaciones nacionales e internacionales relacionados con la Mecánica de las Rocas.

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En la página web de la Sociedad (<https://www.semr.es/organizacion/estatutos/>) se puede consultar el texto aprobado que ha sido correspondientemente depositado en el registro de asociaciones.

Talud en materiales piroclásticos, La Palma, Canarias (© J. Gonzalez-Gallego 2018)



Jornada Extraordinaria – Alicante

El día 30 de enero de 2020 se organizó una Jornada Técnica Extraordinaria en Alicante bajo el título «Riesgos geológicos en la mecánica de rocas: interacción con las infraestructuras». Este evento representó la segunda Jornada Técnica organizada por la SEMR fuera de Madrid. Para esta ocasión, la organización contó con la colaboración del Departamento de Ingeniería Civil de la Universidad de Alicante.

Durante el evento, se presentaron las siguientes ponencias:

- El riesgo de dolinas en infraestructuras. Técnicas de estudio. Francisco Gutiérrez (Universidad de Zaragoza)
- Grandes deslizamientos en la A-7 en el tramo entre Motril y Adra. Javier González-Gallego (CEDEX)
- Estudio de un caso de desprendimientos mediante varias técnicas de análisis y predicción de riesgo. Ignacio Pérez Rey y Leandro Alejano (Universidad de Vigo)
- Monitorización y modelización de una excavación minera del sur de España afectada por un gran deslizamiento. Gerardo Herrera, IGME
- Inestabilidades en formaciones heterogéneas Flysch en infraestructuras lineales. Miguel Cano (Universidad de Alicante)
- Túneles en rocas fuertemente expansivas. Avances recientes. Eduardo Alonso (UPC)



Al evento asistieron más de 80 personas, entre ellas, estudiantes universitarios, profesores y profesionales del sector.

Premio Bienal de la SEMR 2020

El 8º Premio Bienal de la SEMR ha sido concedido a la Dra. Carmen Covadonga García Fernández por su trabajo titulado «*Mecanismo de inicio de la rotura en materiales de comportamiento frágil, bajo condiciones traccionales*».

Esta condecoración bienal premia el mejor trabajo de investigación en el ámbito de la mecánica de rocas realizado por investigadores/as de hasta 36 años y consiste en un diploma y un premio de 3000€.

El tribunal también concedió un accésit del premio al Dr. Ignacio Pérez Rey por su trabajo titulado «*Study of the frictional behaviour of planar sawcut rock surfaces towards a methodology for tilt testing and its application to case studies*».

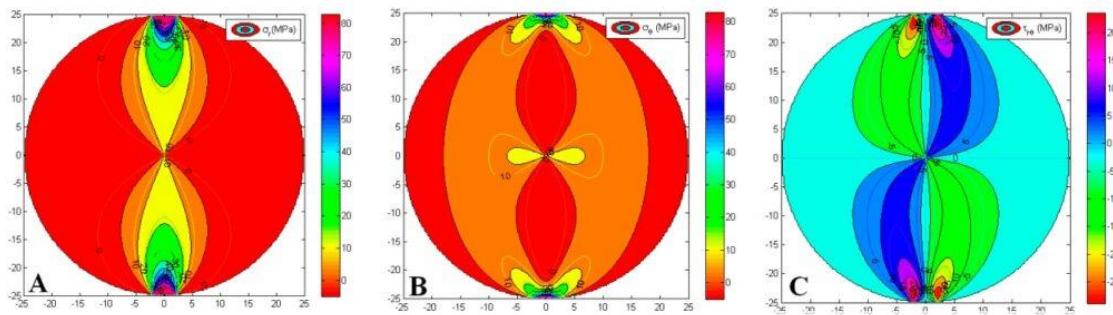


Imagen del trabajo galardonado (C.C. García Fernández 2019)

Roturas en cuña en un talud rocoso, Benavente (CEDEX, 2020)



Eduardo Alonso, Socio de Honor de la SEMR

La Junta Directiva de la SEMR concedió al Profesor Eduardo Alonso Pérez de Ágreda (Departamento de Ingeniería Civil y Ambiental, UPC) la condecoración de Socio de Honor de la SEMR.



Doctor Ingeniero de Caminos, Canales y Puertos por la Universidad Politécnica de Madrid en 1969 y Philosophy Doctor por la Northwestern University en 1973.

Ha enseñado mecánica de suelos, mecánica de rocas, geotecnia y cimientos, probabilidad y riesgo en geotecnia, dinámica de suelos, ecuaciones constitutivas y túneles y excavaciones subterráneas. Ha publicado más de cuatrocientos artículos en revistas internacionales y simposios nacionales e internacionales en los que ha sido conferenciante invitado en múltiples ocasiones. Los temas de investigación incluyen la probabilidad y estadística en mecánica de suelos, mecánica de suelos no saturados, mecánica de rocas y comportamiento termo-hidro-mecánico de suelos, presas de materiales sueltos y estabilidad de taludes.

Es evaluador de revistas internacionales, presidente del Comité ITC106 (Unsaturated Soils) de la International Society of Soil Mechanics and Geotechnical Engineering. Ha realizado más de 200 trabajos como consultor, en España y en el extranjero, sobre excavaciones profundas, centrales nucleares, pantallas, mejoras de terreno, diseño de cimentaciones superficiales y profundas, estabilidad de taludes, recalce de estructuras, reconocimiento del terreno, presas de fábrica y tierra, túneles y almacenamiento de residuos nucleares.

Está en posesión de la medalla "Thomas Telford" (1994 y 2006), máxima distinción concedida por el Institution of Civil Engineers (ICE) del Reino Unido, la "Geotechnical Research Medal" (en 2009 y 2010), ICE, el Crampton Prize (2005), ICE, el Premio José Torán (1995), otorgado por el Comité Español de Grandes Presas, el Premio Narcís Monturiol (2000), concedido por la Generalitat de Catalunya, por sus aportaciones científicas y técnicas a la ingeniería. Ha sido escogido por el Comité Français de Mécanique des Sols et Travaux des Fondations para ser el 2º Conferenciante Coulomb (2003), por la Universidad Texas A & M, para dictar la 11ª Conferencia Spencer Buchanan (2003), por el Georgia Institute of Technology, para pronunciar la 10ª Conferencia Anual Sowers (2007), por la Associazione Geotecnica Italiana, para dictar la 10ª Conferencia Arrigo Croce (2011) y por la International Society of Landslides para pronunciar la 1ª Conferencia Heim (2012).

Fallece el Prof. Manuel Romana Ruiz

El pasado 26 de marzo de 2020 falleció nuestro compañero D. Manuel Romana Ruiz.

A lo largo de su dilatada carrera profesional, el profesor Romana se convirtió en uno de los máximos exponentes de la Mecánica de Rocas tanto a nivel nacional como internacional. Fue socio de la SEMR desde sus inicios, siendo elegido presidente en el año 1980 y nombrado Socio de Honor en 2018.

La Sociedad Española de Mecánica de Rocas lamenta enormemente su pérdida y quiere mostrar su más sentido pésame a todos sus familiares y allegados. Descanse en Paz.



Aquí os dejamos una entrevista que se le hizo a propósito del 50 Aniversario de la Sociedad:
<https://youtu.be/46YggRALMmg>

In memoriam Breve biografía del Profesor Manuel Romana Ruiz

Por: José Bernardo Serón

Hay personas que, por sus méritos y su grandeza, nos parecen gigantes e incluso semidioses que van a estar siempre ahí, como inmortales; pero por desgracia no lo son y un día culminan su paso por este mundo, pues también, por suerte, son humanos, profundamente humanos. Este es el caso de Manuel Romana Ruiz, Dr. Ingeniero de Caminos, Canales y Puertos, Catedrático de Universidad, mi añorado Maestro, mi añorado Amigo, que nos dejó el 26 de marzo de 2020.

Manuel Romana Ruiz nació el 9 de diciembre de 1934 en Sevilla, cosa que a muchos llamaba la atención, dada su imagen cosmopolita, imagen que tenía su fundamento en los múltiples viajes por todo el mundo que realizó y en el hecho de que, a pesar de ser sevillano practicante, fue también catalán de adopción, pues cursó el bachiller (época de la vida que imprime mucho carácter) a medias entre Sevilla y Barcelona (medio curso en Sevilla el otro medio en Barcelona); terminó siendo también Madrileño y Valenciano de adopción y, finalmente, pero no menos importante, fue Asturiano consorte, pues de Asturias fue uno de sus pilares

indiscutibles, su esposa y compañera, María Luisa García Suárez, con la que compartió prácticamente 60 años de su vida.

Al principio de los 50 del pasado siglo, acabado el bachillerato de entonces (ley de 1938) se traslada a Madrid para preparar el ingreso en la Escuela de Caminos. ¿Por qué Caminos si no tenía ningún antecedente ni referencia familiar o próxima? La respuesta nos la dio en una entrevista que realizamos en la Escuela de Valencia con motivo del 50 aniversario a tres profesores de los primeros tiempos de la Escuela, muy significados, y los tres dieron la misma respuesta: "porque era la carrera más difícil". Toda una declaración de intenciones.

En Madrid vivió en una pensión, como otros muchos de los que acudían a la capital para preparar, en alguna o algunas de las academias que a tal efecto existían, el ingreso en una de las denominadas "Escuelas especiales". El programa de las academias para el ingreso en la escuela de Caminos se basaba, fundamentalmente y de manera exhaustiva, en tres materias: Matemáticas, Física y Dibujo ... día tras día. El ingreso era muy duro, extremadamente duro, y a Manuel Romana (y también a los otros profesores entrevistados) le costó 5 intentos, que pueden parecer mucho, pero que no es tanto si se piensa que la media estaba en 8... o en abandono.

Una idea de la dureza de las pruebas de ingreso es la cantidad de aspirantes que se presentaban también a exámenes de ingreso de otras escuelas que generalmente solían aprobar; Manuel Romana se presentó en alguna ocasión, como entrenamiento, al examen de ingreso de Telecomunicaciones, pues era el más parecido al de la Escuela de Caminos y en una de las ocasiones le llamaron, por la calidad de su examen, para ingresar en Telecomunicaciones... pero no, él quería ingresar en Caminos.

Además, aprovechó el tiempo mientras preparaba el ingreso, pues obtuvo la licenciatura en Ciencias Económicas, impulsado por su padre, quien temía que, aunque obtuviese el título de Ingeniero de Caminos, no sería universitario, pues la Escuela, como todas las escuelas especiales en aquellos tiempos, no pertenecía a ninguna universidad, ni siquiera al Ministerio de Educación. Muchos fueron los aspirantes a la Escuela de Caminos que pasaron, como él, por las aulas de la Facultad de Económicas y Romana solía contar anécdotas de los exámenes orales de matemáticas cuando el examinando era uno de esos aspirantes y de las clases que recibió de Manuel Fraga Iribarne, profesor de dicha Facultad.

Tras ingresar en la Escuela en 1955 terminó la carrera casi de un tirón y digo "casi" pues acabó con la promoción de 1961 en lugar de la de 1960, pues, según confesó, en el grupo de teatro que fundó con su amigo Juan Antonio Fernández Ordóñez, coincidió, presentada por Rodolfo Martín Villa, con la que sería su esposa y con la que se casó en 1960.

Finalizando la carrera trabajó en el campo en el que destacaba en aquellos momentos, las estructuras, como becario con Eduardo Torroja, quien le propuso seguir contratado en su oficina, cosa que no aceptó pues tenía mayores aspiraciones económicas que la oferta que le hacía. Romana siempre contaba que Torroja se enfadó con él: "hay que pedir el pan nuestro cada día y no el pan de mañana", le dijo y Romana pensó que se había ganado un enemigo muy poderoso, cosa que no pudo comprobar pues Torroja falleció inesperadamente por una dolencia cardíaca que mantenía en secreto.

Inmediatamente ingresó en la empresa Dragados y Construcciones, trabajando inicialmente en la construcción del Canal principal del Órbigo, para pasar como Jefe de Obra a la Presa de la Barca, y a continuación, también como Jefe de Obra en 1965, a la Presa del Atazar. En estos sus primeros trabajos, como constructor, es donde se despierta su interés por la Geotecnia, principalmente en la Presa del Atazar, que se inició en 1964 con un anteproyecto de Joaquim Serafim y proyecto simultáneo a la construcción, pero que no contemplaba un grave problema de inestabilidad del estribo izquierdo sin cuya resolución prácticamente no se podía ejecutar la obra.

Se puso en contacto entonces con Jiménez Salas quien, con su colaborador, Santiago Uriel, diseñaron un eficaz sistema de estabilización. Y Manuel Romana tuvo ocasión de seguir todo el largo proceso que supuso la definición de la solución (y por supuesto su construcción) y mantener muchas y fructíferas conversaciones con Jiménez Salas y Santiago Uriel.

En 1968 ingresa en la Oficina Técnica de Dragados, que luego pasaría a llamarse INTECSA, donde permanecerá hasta 1987 y donde empezó trabajando en temas geotécnicos de un “modo natural” como decía él, pues como constructor había experimentado la importancia de dichos temas.

Funda en INTECSA el departamento de Geotecnia y Obras Subterráneas, convirtiéndose en uno de los mayores especialistas nacionales en Mecánica de Rocas, pues siguió en su vida profesional el mismo itinerario que la Mecánica de Rocas en la Ingeniería Civil española: primero las grandes presas en la década de los 60, después las grandes autovías (estabilidad de taludes y cimentaciones en roca) en la década de los 70 y finalmente, desde un poco antes de los 80, los túneles, en los que se había centrado desde 1975 estudiando y aplicando las denominadas “técnicas modernas” y el cambio total del enfoque de los macizos rocosos del Nuevo Método Austriaco.

Poco después le llama Jiménez Salas para colaborar con él en la docencia de la Geotecnia en la Escuela de Madrid, junto con Santiago Uriel y para sustituir a Alcibíades Serrano a quien Jiménez Salas había trasladado a Santander para hacerse cargo de la Cátedra de geotecnia de la Escuela de reciente creación.

Ingresa pues en la Escuela de Madrid como PNN donde imparte docencia de la asignatura de Geotecnia durante 8 cursos, del 68 – 69 al 76 – 77. Romana siempre consideró un privilegio colaborar con Jiménez Salas y con Santiago Uriel en la docencia, tres días a la semana, impartiendo las clases en paralelo. Siempre contaba lo enriquecedor de las muchas conversaciones que mantuvieron en el bar de profesores (“entonces lo había” apostillaba) donde se reunían antes y después de las clases.

Romana me contó repetidamente la anécdota siguiente: Jiménez Salas, antes de las clases, les indicaba los contenidos que tenían que dar ese día; Santiago Uriel y Manuel Romana le decían que era materialmente imposible dar todo lo que les proponía en el tiempo que duraba la clase y Jiménez Salas, enfadado, les decía que tenían que hacerlo, fuese como fuese. Lo conseguían, perdiendo el resuello, y al finalizar la clase, de nuevo reunidos en el bar, Jiménez Salas les decía, con una sonrisa de oreja a oreja, que tenían razón, que no se podía dar todo lo planteado en el tiempo de duración de la clase.

En 1977 gana, por oposición, la “Cátedra del Grupo XV” de Geotecnia y Cimientos, de la Escuela de Santander, donde imparte docencia hasta el curso 1979 – 1980, para pasar por concurso de traslado a la Escuela de Valencia en el curso 1980 – 1981, donde se hace cargo de la asignatura “Geotecnia y Cimientos” de 4º curso y de “Mecánica de Rocas” de 5º, que pasa al plan de 6 años bajo la nueva denominación de “Mecánica de Rocas y Túneles”, además implementa una nueva asignatura: “Geotecnia de las Obras Hidráulicas”.

En las asignaturas optativas, que en aquellos momentos tenían un número reducido de alumnos, en torno a 10 o 12 e incluso menos, introduce toda una “revolución” docente para la época: baja la mesa del profesor de la tarima al nivel de los pupitres y distribuye estos en forma de U con el extremo abierto hacia la mesa del profesor, instalando una pizarra tipo “vileda” tras dicha mesa donde proyectaba sus famosas “diapositivas” y “transparencias” que constituyan (y constituyen, pues aún se conservan) una grandísima colección de imágenes de todo tipo relacionadas con la Geotecnia.

Instauró las prácticas de campo de Mecánica de Rocas y Túneles de las asignaturas que, con diversas denominaciones, impartió en los distintos planes de estudio, junto con numerosas visitas técnicas a obras (fundamentalmente túneles en construcción) e incluso viajes de estudio de varios días de duración.

Cuatro actividades eran prácticamente fijas año tras año: en primer lugar, el estudio del afloramiento rocoso a los pies del Monasterio de Santa María del Puig, en segundo lugar las estaciones geomecánicas y estudio de túneles y taludes en la línea de ferrocarril Valencia – Barcelona entre Oropesa del Mar y Benicasim y, finalmente, primero visitando las obras en construcción los primeros años (en las que intervino activamente como Director de INTECSA) y después con los tramos de autopista ya construidos, estudiando sus desmontes (el “Desmonte del Indio” con su falso túnel, el singular e impactante “Deslizamiento del Rabat”, etc.) y sus túneles (los de Xeresa y los del Mascarat) y el curioso túnel peatonal urbano de Denia, junto con las actuaciones de consolidación del talud del macizo rocoso del Castillo, de las que fue autor.

Siempre que se podía y se disponía de fondos en la Cátedra, o si alguna empresa lo financiaba, se terminaban las prácticas de campo o las visitas técnicas en torno a una mesa con los alumnos; famosos fueron los arroces

a banda del Turk (ya desaparecido) en el Grao de Castellón o la paella, cortesía de Aumar, en el Área de Servicio de La Safor. Los primeros años también organizó, mientras el número de alumnos lo permitía (terminó habiendo más de 60 alumnos matriculados en la optativa de Túneles y Obras Subterráneas) un “viaje de estudios” de una semana de duración, que se realizaba con cuatro o cinco coches particulares, sufragando la Cátedra y/o la Escuela el combustible y el alojamiento... las comidas corrían a cuenta de las empresas cuyas obras se visitaban. Estos viajes cubrieron prácticamente toda España, del norte al sur y del este al oeste, siendo uno de ellos en Andorra la Vella y en Francia, viendo obras de Électricité de France (EDF).

Pero no solo centró sus esfuerzos en la docencia “reglada” de la Escuela; desde el principio desarrolló una actividad, casi frenética, de impartición cursos de postgrado. Los primeros, a principios de los 80 versaron sobre cimentaciones profundas, sobre presas de materiales sueltos y, sobre todo, sobre diversos aspectos del proyecto y construcción de túneles (sobre emboquilles, sobre revestimiento de túneles, sobre el Nuevo Método Austriaco, sobre túneles en condiciones difíciles, etc. etc.), cursos que tuvieron una aceptación inusitada, superándose de largo el centenar de participantes en todas las ediciones.

En los años 90 y primera década de este siglo continuó con los cursos de postgrado, pero esta vez añadiendo a los temas relacionados con los túneles. Los centrados en la Mecánica de Rocas, en la estabilidad de taludes, en los denominados entonces “métodos modernos de mejora del terreno”, en la patología y recalce de cimentaciones, en los micropilotes... Estos cursos se impartían tanto en la Escuela de Valencia como en la demarcación del Colegio de Caminos en Valencia, o en Madrid, a cargo de su oficina técnica (STMR: Servicios Técnicos de Mecánica de Rocas), con el patrocinio en ocasiones de diversos organismos y empresas y siempre con el apoyo del Colegio de Caminos.

Fue el principal impulsor del Máster de AETOS en Túneles y Obras Subterráneas de la Universidad Politécnica de Madrid (actualmente en la UNED) y dirigió las dos primeras ediciones. Asimismo, fue director del Curso Universitario de Postgrado “Túneles: Construcción y Asistencia Técnica” de la Universidad Politécnica de Madrid, que se impartía en la Escuela de Ingenieros Técnicos de Obras Públicas.

Estuvo impartiendo docencia en la Escuela de Valencia hasta el día de su jubilación, el 28 de febrero de 2010, con 75 años, tras 5 años de Profesor Emérito (en realidad tenía que haber estado 6: 3 años concedidos por la Universidad y una ampliación a otros 3 concedidos por el Consejo Social, pero un cambio en la reglamentación, aplicado con carácter retroactivo, le impidió la docencia el sexto año).

Toda esa actividad docente la compaginó con el desarrollo de su actividad profesional y en la actividad en entidades ajena a la Universidad. Fue de la Junta Directiva de la SEMSIG, socio activo de AETOS, miembro del Comité Español de Túneles de Carreteras de la ATC – PIARC y representante español en el Comité Internacional de Explotación de Túneles de la PIARC, como Primer Secretario de Idioma Español. Formó parte de la Junta de la Demarcación del Colegio en la Comunidad Valenciana.

Accedió a la Presidencia de la SEMR en 1980, siendo el cuarto presidente de la Sociedad (tras Jiménez Salas en 1967, Alejandro del Campo Aguilera en 1971 y Santiago Uriel en 1975), permaneciendo como Presidente hasta el 2001, aunque no fue fundador ni participó en la fundación en 1967, como él aclaró en diversas ocasiones. En la primera década de su presidencia se continuó con la gran actividad de eventos llevados a cabo en la década anterior, que contaron también con su participación, que culminó con el Congreso Internacional de la ISRM en 1988.

Fue también un viajero incansable y asiduo a los principales eventos del mundo de la Geotecnia y en especial de la Mecánica de Rocas, donde coincidió en innumerables ocasiones con los más destacados miembros de la comunidad científica: Bieniawski, Barton, Hoek, ...por citar algunos.

En cuanto a la actividad profesional, como se dijo anteriormente ingresó en INTECSA en 1968, permaneciendo hasta 1987 como director del Departamento de Geotecnia y Obras Subterráneas. En ese periodo participó en innumerables proyectos nacionales y extranjeros.

En 1987 funda la empresa INGEOTEC (Ingeniería y Geotecnia), especializada en Obras Subterráneas y Estudios Geotécnicos, en cuyas oficinas se proyectan más de 500 km de túneles de nueva planta, carreteros, urbanos, de metro, de ferrocarril convencional y de alta velocidad e hidráulicos, y multitud de informes sobre reparación

y conservación de túneles, estabilidad de taludes y estudios geotécnicos en general, entre los que cabe destacar los trabajos geotécnicos para la primera gran ampliación del Puerto de Valencia. La primera época de INGEOTEC, en la que tuve el honor de participar asiduamente como colaborador, fue inolvidable, dirigida con mano maestra por Romana.

Finalmente, a principios de este siglo creó STMR (Servicios Técnicos de Mecánica de Rocas) con que continuó su actividad profesional y con la impartición de cursos de postgrado.

Otra faceta en la que destacó fue en la investigación en el campo de la Mecánica de Rocas y en el campo de los túneles. Es mundialmente aceptada y extendida la clasificación para taludes en roca SMR (Slope Mass Rating), que presentó a nivel nacional en Barcelona, en el 3er Coloquio sobre Ingeniería Geológica de mayo de 1985 en la UPC y a nivel internacional en el Congreso de la ISRM en Zacatecas, México, en septiembre de ese año. Con el paso del tiempo, cada vez que preparábamos algún artículo sobre el SMR, Romana solía decir que más que el padre del SMR se sentía el abuelo del SMR.

Especial cariño tenía Romana a otra de sus creaciones, menos conocida por su más reducido campo de aplicación, la clasificación para la revisión de la seguridad de la cimentación de presas DMR (Dam Mass Rating), presentada en el año 2003 (aunque estuvo trabajando con anterioridad en ella) con una buena aceptación por parte del Comité Español de Grandes Presas.

En el caso de los túneles, la gran aportación de Romana han sido sus nuevas recomendaciones para el sostenimiento de túneles según el RMR (una puesta al día de las de Bieniawski) y las recomendaciones para el emboquille, ambas aportaciones han sido adoptadas por multitud de consultores y proyectistas. Además de todo eso publicó más de cien artículos técnicos en Simposios y Congresos, nacionales e internacionales y en revistas y boletines técnicos, mayoritariamente nacionales (todavía no existía la actual “obsesión de los Q1”).

Obtuvo la Medalla al Mérito Profesional del Colegio de Caminos, y el 26 de marzo de 2008, en un acto celebrado en la embajada de Austria, la embajadora Doña Ulrike Tilly le impuso la “Gran insignia de honor en plata al mérito por la República de Austria” concedida por el Presidente de la República de Austria, por las aportaciones realizadas al llamado “Nuevo Método Austriaco de construcción de túneles”. Y el 9 de febrero de 2018 fue nombrado Socio de Honor de la SEMR.

En la última etapa de su vida sufrió dos reveses importantes. Por una parte, desde el punto de vista laboral, pese a su edad, el hecho de reducirse notablemente su nivel de actividad (casi totalmente a excepción de algunos trabajos y cursos y conferencias en México), a causa de la crisis de la construcción de 2008; se quejaba amargamente de no tener trabajo, pues siempre expresó su temor a la inactividad en la vejez.

Por otra parte, desde el punto de vista familiar, la enfermedad de pronosticó totalmente negativo de su inseparable y querida esposa, enfermedad en la que Manuel Romana estuvo al pie del cañón y que final e inesperadamente María Luisa superó, pero posteriormente sufrió un ictus del que ya no se recuperaría, falleciendo el 16 de agosto de 2017.

Manuel Romana se retiró ya de la vida pública instalándose en el piso de Ponzano que fue la sede inicial de INGEOTEC; la última vez que lo visité en mayo de 2019, lo encontré estupendamente, feliz y sonriente, totalmente adaptado a su nueva vida y, como siempre buen conversador, comimos juntos y se prolongó la sobremesa más de tres horas; me despedí diciéndole que volvería a verle en mi siguiente viaje a Madrid, como muy tarde en abril, cuando la jornada de la SEMR del 2020... pero no fue posible.

Dice la conocida canción que “algo se muere en el alma cuando un amigo se va”, y es verdad y se agrava si además es tu maestro, que tanto te enseñó, con el que has mantenido multitud de conversaciones, con el que has trabajado tanto en las labores docentes en la universidad y en los cursos de posgrado como en los trabajos profesionales bajo su dirección, durante casi 40 años de tu vida y que sigues echando de menos no tenerlo a tu lado en el día a día de la docencia y no poder seguir aprendiendo de sus enormes conocimientos y de su saber hacer.

Reunión del *Board* de la ISRM en Ljubljana

El presidente de la SEMR y Vicepresidente para Europa de la ISRM, Leandro R. Alejano, participó recientemente el 31 de enero de 2020 en el Workshop titulado avances recientes en mecánica de rocas celebrado en Ljubljana (Eslovenia) con una asistencia de 120 miembros de la ISRM de este país y los países balcánicos del entorno. En esta jornada se realizaron presentaciones por varios miembros del Board de la ISRM.

RECENT TRENDS IN ROCK MECHANICS

LJUBLJANA • RADISSON BLU PLAZA HOTEL • 31ST JANUARY 2020



Presentación de la jornada

Eslovenia es un país situado entre los Alpes austríacos y los Balcanes caracterizado por una geología kárstica y en él se desarrolló parte de los conocimientos científicos de este tipo de materiales rocosos; siendo famosas alguna de las cuevas kársticas más grandes del mundo como Postojna o Skocjan.

En los siguientes días 1 y 2 de febrero tuvo lugar la reunión de Board de la ISRM donde se trataron temas de trámite de la Sociedad decidiéndose sobre la aprobación de las comisiones de trabajo y recomendaciones a las mismas, la organización para la selección de la Rocha Medal del próximo año y otros premios.

En este sentido cabe destacar que para la concesión del nuevo premio “Science Achievement Award”. Los Premios de Ciencia y Tecnología de ISRM se otorgarán a individuos o empresas de asociadas a la ISRM, en reconocimiento a sus contribuciones sobresalientes a la ciencia y la tecnología en el campo de la mecánica e ingeniería de rocas. La normativa se puede consultar en el siguiente enlace web se pueden presentar candidaturas hasta el 15 de febrero:

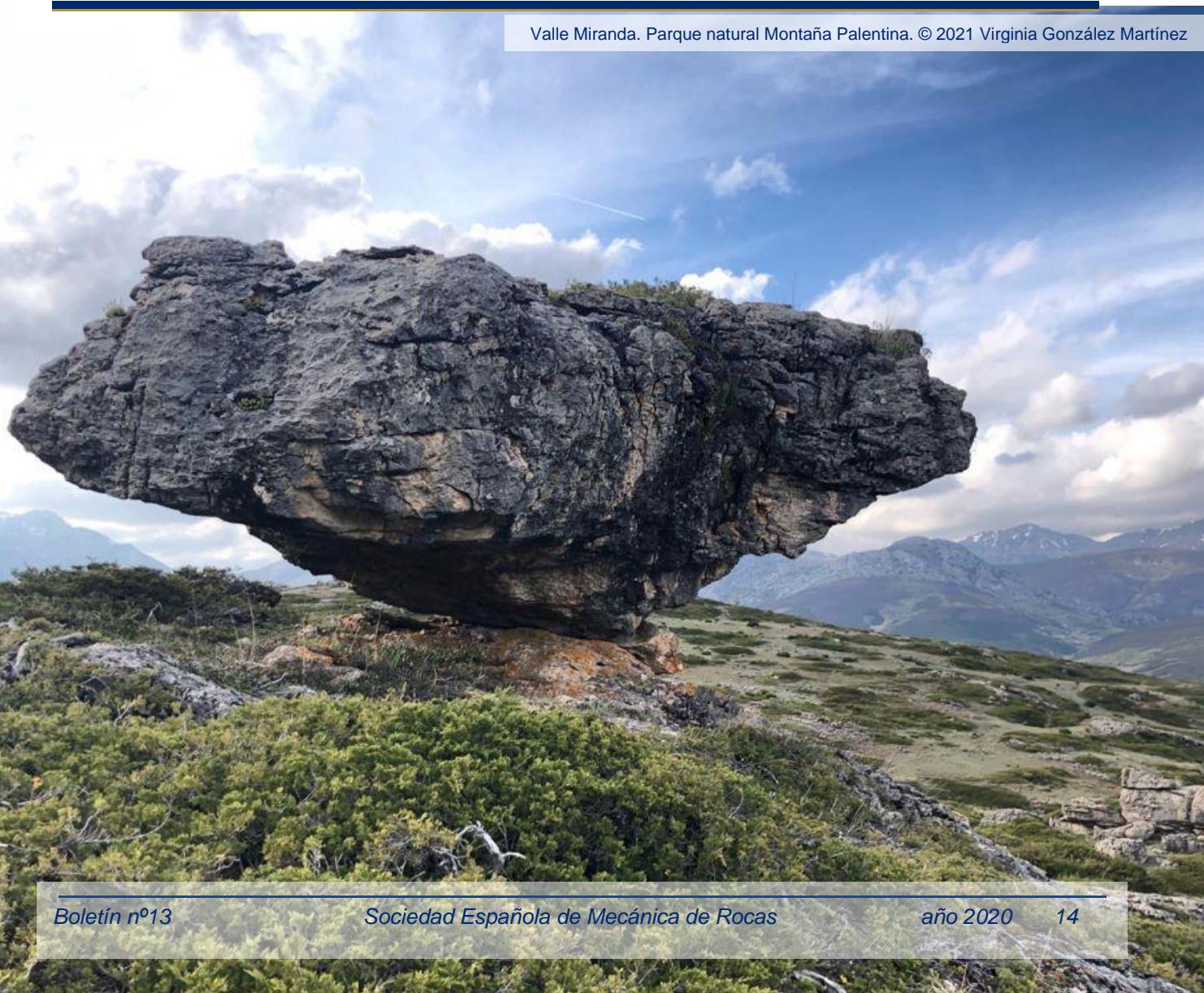
https://www.isrm.net/fotos/noticias/ISRM_Science_and_Technology_Awards.pdf

La siguiente reunión del Board se celebrará en paralelo con el próximo congreso EUROCK 2020 los días 12 y 13 de junio de 2010, que será además internacional en la ciudad de Trondheim (<http://www.eurock2020.com/>).



Board reunido en Ljubljana. Atrás de pie y de izquierda a derecha: Ömer Aydan (VP at large), Leandro Alejano (VP Europa), Sofía Mess (administrativo de la ISRM), Michael du Plessis (VP Africa), Laura Pyrak-Nolte (VP Norte América), Sevda Dehkhoda (VP Australasia), Luís Lamas (Secretario general de la ISRM), José Pavón (VP Sudamérica). Delante sentados Suseno Kamadibrata (VP Asia), Resat Ulusay (Presidente) y Vojkan Jovicic (VP at large). Faltó Yang Qiang (VP at large), de China por temas de prudencia sanitaria.

Valle Miranda. Parque natural Montaña Palentina. © 2021 Virginia González Martínez



Resumen de los artículos presentados por españoles al EUROCK 2020

Applicability of point load test to estimate unconfined compressive strength and Young's modulus of dry and saturated porous building stones.

Rabat, Á.; Cano, M.; Tomás, R.

Point load test (PLT) is a widely used indirect method to estimate the unconfined compressive strength (UCS) of rocks in geotechnical practice. The test consists of loading a rock specimen between two conical platens until failure occurs in order to calculate the point load strength index ($Is(50)$). Its main advantages are the simplicity of the test, the flexibility in terms of the specimen's shape and size, the low cost and the possibility of being performed in the laboratory or the field. In this line, many authors have obtained correlations between $Is(50)$ and UCS for different rock types. However, limited works have been conducted in soft or weak rocks such as porous building stones with UCS values lower than 40 MPa and very few studies have examined the relationship between $Is(50)$ and elastic Young's modulus (Est) or the water saturation effect on these properties and the corresponding correlations. This study tries to close these gaps by establishing correlation functions to infer UCS and Est in term of $Is(50)$ for porous building stones from Alicante (Spain) in dry and saturated conditions. Concerning the results, significant correlations were obtained for dry, saturated and both dry and saturated specimens, demonstrating the applicability of PLT to predict the strength and the deformability of these rock materials. Finally, the findings were also compared with other previous studies.

Using the needle penetration test to determine strength and deformability of dry and saturated siltstones

Rabat, Á.; Cano, M.; Tomás, R.; Tamayo, Á.E.; Alejano, L.R.

The preparation of standardized samples of soft rocks for the development of uniaxial compressive strength (UCS) test is usually difficult, expensive and time-consuming. Needle penetration test (NPT) was originally developed in Japan as an alternative for the indirect estimation of uniaxial compressive strength of soft rocks. The needle penetrometer is a portable, simple and non-destructive testing device which can measure the applied load and the penetration depth of the needle on the rock in order to calculate the needle penetration index (NPI). In this work, the applicability of NPT to obtain the UCS and the static Young modulus (Est) in dry and saturated siltstones from Alicante (SE Spain) is evaluated. In addition, a comparison with previous works published in scientific literature is

performed. The results show significant correlation functions to infer UCS and Est in terms of NPI in dry and saturated siltstones. Furthermore, a similar water sensitivity (measured as percentage of loss) of NPI, UCS and Est was obtained, indicating that NPI is an appropriate index to evaluate the changes in strength and deformability caused by water saturation. These facts make NPT especially useful to estimate the mechanical parameters of natural or artificial historical rocks structures, heritage and ancient monuments under protection and the monitoring or restoration of stone buildings in a non-destructive and fast way.

Study of Explosive Behaviour at High Temperatures on Limestones from a Road Tunnel in Spain.

Víctor Martínez-Ibáñez, María Elvira Garrido, Carlos Hidalgo Signes, Roberto Tomás

The experience gained in the 1999 fire catastrophes in the Tauern (Austria) and Montblanc (France) tunnels, as well as full-scale tests and investigations reveal the effect of high temperatures on the weakening of rock structures in tunnels. The effect of high temperature on tunnel lining has been studied profusely. Investigations are less numerous on the effect on rock mass, and these have focused on the reduction in the strength and the variation of the elastic properties of the rock with temperature. This research focuses on limestone samples from boreholes made for a road tunnel in the south zone of the Catalan Pyrenees (Spain). It has been observed that, for certain geochemical compositions, some rock samples explode violently when heated to certain temperatures. This phenomenon is not considered in international regulations and, therefore, it is not taken into account in the design, operation, or performance of emergency services. A description of the potentially explosive rock is given. The activation temperature and the geochemical composition before and after an explosion are determined. The results facilitate the early identification of this type of material, and the implementation of safety measures in the early stages of the life cycle of this type of infrastructure.

Indirect Evaluation of Strength for Limestones Subjected to High Temperatures.

Víctor Martínez-Ibáñez, María Elvira Garrido, Carlos Hidalgo Signes, Roberto Tomás

Experience gained from the most relevant fire catastrophes on road tunnels, and research on the effect of high temperatures on rock, show that heating causes the weakening of rock and this implies great risk for people and

infrastructures. Finding indirect methods for evaluating the decrease in strength induced by temperature in intact rock could facilitate damage analysis and reparation phases after a tunnel fire. The research developed in this work involves laboratory tests carried out on samples of limestone from the south zone of the Catalan Pyrenees (Spain). The samples have been heated to different temperatures under laboratory conditions. Changes in their mass, volume, dry density, and P-wave velocity have been evaluated to find relationships with the variation in uniaxial compressive strength. Simple regression functions have been selected, as they are easy to use, and provide quick indicative values that could be critical after a fire in a tunnel. The influence in the precision of the data obtained in laboratory tests for the various correlations has been also studied. Variation of dry density and P-wave velocity predict strength variation values lower than those experimentally observed. Predictions using dry density variation appear to be sensitive to the precision of the data obtained in the laboratory tests. The variation of open porosity offers the best correlation among those considered in this research. The evaluation of open porosity involves a simple laboratory procedure, and simple potential regression enables quickly computing indicative values to evaluate the degree of damage to this specific type of rock when heated to high temperatures.

Anisotropic strength of the fault gouge of the Alhama de Murcia active fault (se spain)

J. M. Insua-Arévalo; M. Tsige; J. L. Sánchez-Roldán; E. Rodríguez-Escudero; J. J. Martínez-Díaz

The Alhama de Murcia Fault (AMF) is an active fault located in the SE of Spain. This fault developed a ~80 m thick band of highly deformed clay rich gouge with a marked tectonic fabric (foliated gouge) that constitute a notable anisotropy.

In this work we present the result of consolidated-undrained triaxial tests (CU) performed under low confining pressure (50, 150 and 300 kPa) to several sets of core specimens carved with different orientation of the tectonic fabric. We analyse strain-stress relationships of each test, as well as failure modes, obtaining a brittle behaviour at lowest confining pressure, and ductile at highest. The resistance results show that the gouge of the AMF behaves as a hard soil or very soft rock. Those results are adjusted by the non-linear Hoek&Brown criteria for every orientation by considering two working hypotheses: (i) considering the fault gouges as intact rock, and (ii) considering the fault gouge as tectonised rockmass. Both working hypotheses are consistent, reaching maximum values of resistance when axial load (σ_1) is applied perpendicular to the foliated planes of the gouge, decreasing for lower angles with the anisotropy planes which favour failure. Anisotropy index R_c has been estimated in a range between 1.40 and 3.16, which classify the fault gouge as low to medium anisotropic behaviour. Nevertheless, results from specimens with the tectonic fabric oriented most favourably for failure occurrence do not fit such a pattern, since strength for this orientation is greater than intermediate orientation. Such an anomalous result could be related to an increase in the roughness of the failure planes controlled either by the presence of larger fragments of protolith or by an asymmetry on the roughness of the weakness planes related

to the original microscale structures characterized by a strong reorientation of clays.

These results will be useful to applications related to slope and tunnel stability, and also to the understanding of the relationships between aseismic creep deformation and earthquakes nucleation within the AMF.

Characterization of joint roughness using long-range terrestrial photogrammetry

R. García-Luna, S. Senent; R. Jimenez

The Joint Roughness Coefficient (JRC) is probably the most common tool to characterize joint roughness in practice. However, its visual assessment by means of Barton's comb can be quite subjective and it also requires direct contact with the rock mass while measurements are taken, increasing the time for data acquisition and the risk for the workers' safety. Therefore, remote 3D non-contact techniques -such as digital photogrammetry or laser scanner methods (LiDAR)- to measure surface roughness from high-resolution 3D models have become very popular in the last years. However, the long distance applicability of digital photogrammetry has not yet been investigated in detail. In this paper, we present a digital photogrammetry application for remote characterization of rock joint roughness using long-range photogrammetry and statistical analysis. In particular, we employ the Structure from Motion (SfM) technology -a technique that allows us to use regular cameras, generating 3D point clouds using information from photographs and a specific software- to construct 3D models of the joint surfaces at different distances. Then, we are able to extract roughness profiles of the region of interest from the 3D data. Finally, the JRC value of those profiles are computed using an empirical correlation with Z2, a parameter previously proposed to characterize joint roughness. The proposed methodology is applied to a real case in an ancient open-cast mine in Northern Spain. The results obtained at different distances and with different camera configurations are compared to analyze the potential of photogrammetry to develop accurate long-distance models. Results show that zoom lenses make it possible to characterize joint roughness at long distances.

Digitalisation of rock specimens and outcrops for training

A. Riquelme; J. L. Pastor; M. Cano; R. Tomás; D. Benavente; L. Jordá

Three types or classes of rocks are commonly used for rock classification according to its genesis: sedimentary, igneous and metamorphic. Their classification is based on some characteristics of rocks such as composition, texture, strength, etc. Experienced users can identify rocks observing certain features (colour, grain size, foliation, presence of fossils, etc.), but non-experts may require training to reach this competence. Several resources are available on the Internet and on the scientific and teaching literature presenting photos of rocky specimens. However,

the experience of handling a rock on hands not only provides more information of the specimen but also makes the main characteristics of the rock easier to remember. The form of an outcrop depends, among other factors, on the lithology (i.e., presence of bedding planes, weathering, discontinuities, etc.). In both cases, digital 3D models of rock specimens and rocky slopes aid the users to train their abilities and recognition skills. We present a benchmark to aid the training process that classifies the rocks and outcrops using a textural classification. It allows inspecting the 3D textured models of rocks and slopes along with a behavioural classification. Two techniques were used to generate the models: 3D laser scanning (3DLS) and structure from motion (SfM). 3DLS-derived datasets are a 3D point cloud used to generate a 3D mesh over which the texture is superposed from the digital photos. To generate the SfM datasets we used digital photos, and therefore the process incorporates the texture. The benchmark is open access and collaborative in the URL: <https://web.ua.es/digitalrocks>, and it is being used by geology and engineering students for their training.

Discontinuity mapping with photogrammetry and televIEWER for blastability assessment

P. Segarra; J. A. Sanchidrián; M. Bernardini; S. Gómez; A. P. Pérez-Fortes; C. Paredes, J. Navarro

Photogrammetry and optical televIEWER are used to investigate discontinuities occurring in the highwall of the bench and in eleven blastholes in two blasts. The measuring conditions involve lower resolution for photogrammetry models. Discontinuity mapping was done manually by the same operator. The main rock mass characteristics considered to predict fragmentation from rock blasting (i.e. discontinuities' orientation and spacing) are obtained from each of these tools. Discontinuities' spacing has been assessed in photogrammetry models along a dense set of scanlines oriented in four directions along the bench face. The blasthole axis itself is the scanline for televIEWER measurements.

The orientation of discontinuities is investigated from density contour plots of the poles of the discontinuities measured by both techniques. A sub-horizontal set is observed with both techniques in both blasts, while the number and orientation of sub-vertical sets is different. A procedure to calculate a fracture orientation index for fragmentation prediction models has been applied to the measured discontinuities. The resulting indexes from both techniques in one blast are very similar, while a difference of 14 % occurs in the other blast.

Gates-Gaudin-Schuhmann (GGS) and Weibull-Rosin-Rammler (WRR) functions have been fitted to the cumulative distribution functions of discontinuities spacing. Both can represent the spacing data within a limited range, this being narrower for the GGS. The determination coefficients are generally higher for the WRR function, despite the broader range of the fit. Differences in the resolution of the measuring techniques involves a median spacing or scale factor of the WRR function of about 1 m for photogrammetry, and 0.3 m for televIEWER. The shape factors of the WRR function from televIEWER logs are in line those from scanlines of photogrammetry models. This

suggests a scale-invariant behaviour of the discontinuity pattern in the rock mass for the techniques analysed.

Effects of thermal gradient on limestone exposed to high temperatures

M. E. Garrido; V. Martínez-Ibáñez; C. Hidalgo; S. Di Biase; R. Tomás

The variation of the physical and mechanical properties of limestone after high temperature treatment has become a major issue of interest for a number of reasons, such as tunnels safety, protection of historical monuments affected by fires, and geothermal energy. Therefore, an understanding of the effects of temperature on the variation of rock properties is of paramount importance. There is no standard procedure to evaluate the effect of temperature on rocks. Different methodologies are described in the literature, and consequently, a unified procedure should be defined to evaluate the damage on rocks exposed to fire. An ideal test must mimic the real phases of a fire: heating; maximum temperature maintenance time; and cooling. The thermal gradient determines the first phase. Until now, each investigation has used a different heating velocity to reach the target temperature, varying between 2 and 120 °C/min. Theoretical fire curves show that thermal gradient is much higher than gradients usually used in laboratory experiments. For this reason, the effect of heating velocity must be studied in depth. This paper shows the effects of three different thermal gradients (i.e. 5, 10 and 15 °C/min) on a limestone exposed to three different target temperatures (400, 600 and 800 °C). To evaluate the effect of thermal gradient, samples of limestone were tested after heating to calculate porosity, density, dynamic elastic modulus, and unconfined compressive strength. The main goal of the paper is to compare the thermal damage produced by each gradient and evaluate the influence of the gradient on these properties.

Geotechnical lithotypes of volcanic rocks

J. González-Gallego; B. Ruiz Morón; M. Muñiz-Menéndez

Due to their genesis, volcanic rocks show some unique features that differentiate them from other lithologies, such as sedimentary or metamorphic, in numerous aspects. In the past few decades, there has been an important development in the knowledge of the geotechnical behaviour of volcanic rocks, mainly regarding the matrix rock.

The need to classify the different types of volcanic rocks according to their geotechnical behaviour has led many authors to propose different geotechnical lithotype classifications. Many of these classifications are local and have been developed keeping the specific characteristics of a particular region in mind.

Moreover, a difficulty arises when applying the main geotechnical classifications (RMR, GSI and Q indexes) to volcanic rocks, so the results obtained may have a high degree of uncertainty.

This paper presents an extensive literature review of geomechanical data from volcanic rocks, completed with the authors' data from MACASTAB project.

In addition, after a critical review of the main existing geotechnical lithotype classifications, the first version of a new classification is proposed, which tries to cluster volcanic rocks globally according to their geotechnical behaviour, known from the geomechanical data compiled.

Indirect evaluation of strength for limestones subjected to high temperatures

V. Martínez-Ibañez; M. E. Garrido; C. Hidalgo Signes; R. Tomás

Experience gained from the most relevant fire catastrophes on road tunnels, and research on the effect of high temperatures on rock, show that heating causes the weakening of rock and this implies great risk for people and infrastructures. Finding indirect methods for evaluating the decrease in strength induced by temperature in intact rock could facilitate damage analysis and reparation phases after a tunnel fire. The research developed in this work involves laboratory tests carried out on samples of limestone from the south zone of the Catalan Pyrenees (Spain). The samples have been heated to different temperatures under laboratory conditions. Changes in their mass, volume, dry density, and P-wave attenuation have been evaluated to find relationships with the variation in uniaxial compressive strength. Simple regression functions have been selected, as they are easy to use, and provide quick indicative values that could be critical after a fire in a tunnel. The influence in the precision of the data obtained in laboratory tests for the various correlations has been also studied. Variation of dry density and P-wave attenuation predict strength variation values lower than those experimentally observed. Predictions using dry density variation appear to be sensitive to the precision of the data obtained in the laboratory tests. The variation of open porosity offers the best correlation among those considered in this research. The evaluation of open porosity involves a simple laboratory procedure, and simple potential regression enables quickly computing indicative values to evaluate the degree of damage to this specific type of rock when heated to high temperatures.

Numerical and experimental characterization of mechanical behaviour of an artificially jointed rock

N. A. González-Molano; J. Alvarellos; M. R. Lakshmikantha; J. Arzúa; L. R. Alejano

Modelling of rock masses is important to assess the geomechanical behaviour of oil & gas reservoirs, especially in fractured tight reservoirs. The presence of discontinuities will significantly influence the general behaviour of the rock masses. In order to achieve realistic simulation process a good knowledge of rock behaviour is required together with calibration or matching data of actual and controlled tests on rock. Artificial saw-cut joints on granitic rock specimens have been used to simulate a rock mass analogues at the laboratory scale with the aim of attempting to identify and quantify pre- and post-peak behaviour trends for different levels of confinement and jointing. The mechanical behaviour of intact and jointed rock samples are studied

using an equivalent continuum modelling approach and a discrete approach. Advantages and limitations of each numerical approach are identified and give us an insight into the response of rock masses modelling at engineering scale.

Permeability measurements in fissured rock samples at variable confinements

L. R. Alejano; X. Estévez-Ventosa; J. Delgado-Martín; V. Blázquez-Pascual; N. A. Glez.-Molano; J. Alvarellos; J. Canal-Vila

The main aim of this study is the setting up of a laboratory system capable of testing fissured rock specimen permeability at different stress levels. To achieve this objective, a hydraulic press frame with associated Hoek's cell has been upgraded with servo-controlled pumping, pressure meter and external liquid weighing scales. Accordingly, and once a porous or fissured rock specimen is submitted to a particular triaxial stress state, it is possible to make water flow through it. This is done by inducing fluid pressure in its upper base and automatically weighing the fluid passing through the specimen, so the hydraulic conductivity can be computed. As a first application, porous sandstone samples were tested. We check that the permeability values obtained agree well with permeability estimates of this rock reflected in the literature. In the next step, tests on artificially jointed (1 sub-vertical + 2 sub-horizontal or 1+2) intact granite samples were performed. Similar samples were mechanically tested by the authors in the past. Results showed a relevant dependence of permeability with confinement, but independence from the major principal stress. Eventually we carry out the tests in 1+2 and 2+3 jointed samples, submitting specimens to increasing confinement from 1 to 20 MPa. Results are compared against Klinkenberg permeability values from tests with gas showing a good agreement.

Predicting rock mass conditions ahead of tunnel face and the use of geostatistical methods. A comparative study

S. Sánchez Rodríguez; G. Sampedro; J. D. Fernández; J. D. López

Intrinsic uncertainty associated to geology of rock masses along with the lack of standardization in the field of tunnel ground investigation and rock quality predictions during design and planning, are some of the reasons related with budget deviations and schedule delay problems in tunnel excavations which usually end with the miscarriage of important projects. The use of geostatistical tools supporting traditional 'experienced geologist' way of forecasting ground conditions can help to limit uncertainty in some cases. This study includes an analysis on the use of these techniques for different lithologies and work phases along with the combination of face mapping data with borehole and other superficial investigation.

Rock mass characterization for CAES system applications and analysis of the behaviour with cyclic loads

M. I. Álvarez-Fernández; C. González-Nicieza; M. B. Prendes-Gero; J. C. Peñas-Espinosa

All over the world a change in the energetic system is been developed and renewable energies are improving their presence. Both the variability of this kind energies and the higher price of energy in the peak hours of demand, creates the need for energy storage. One of the most suitable technologies to counteract the effects of hourly and daily intermittency are the Compressed Air Energy Storage (CAES) which is based on compressing the air in a natural or artificial underground storage (abandoned mines, cavities in mineral solutions or aquifers).

The main geotechnical criteria that must be presented by rock masses in order to build a storage system is: high strength, low permeability and adequate volume (size). However, fatigue behaviour is not often evaluated, while it can be critical for this kind of application. High pressure charges and discharges can occur daily.

The aim of this work is to determine the possibility of implementing a system of storage of energy based in compressed air in abandoned mines. The limit pressure of the storage is firstly defined in an analytical way, function of the properties of the rock mass and then, based on numerical codes.

At last, a methodology, to evaluate the fatigue behaviour due to cyclical loads and discharges, is proposed. This methodology is based on the reduction of the geotechnical properties of the rock mass linked to the changes in joint conditions.

Rock slope stability study case: ruínas de Huanchaca south sector, Antofagasta, Chile

H. Bravo; S. A. Zepeda; J. Arzúa; J. González; M. Cánovas

The south sector of *Ruinas de Huanchaca* (or Huanchaca Ruins) features a rock slope of around 850 m in length with a height of around 30m. The Huanchaca Ruins are the remains of an ancient silver foundry complex built in 1892 and abandoned in 1902. It is an important monument in Antofagasta, Chile. The Huanchaca Ruins and the land on the toe of the slope belongs to the Catholic University of the North. We started this preliminary stability study because there are citizens living above and working below the rock slopes. The safety of these people is a concern because there is a lack of previous information of the rock mass, poor monitoring (mainly based on satellite photographs) and regular seismic activity. Therefore, this study is aimed to perform a preliminary study of the stability of the slope in order to identify potential slope failures.

A field survey of discontinuities gave us a primary division of the slope, and drove us to dividing the study area in 7 zones. Potential slope failure mechanisms were identified on four of these zones. Another zone did not show any evidence of potential failure and the remaining two zones were not accessible. On field, 3 geological areas are identified, being andesite and weathered andesite the dominant rocks. Laboratory tests on rock fragments from the slope were

performed in order to provide information of the intact rock and the discontinuities.

Stability analyses were performed using analytical approaches and the Rocscience software when available. Calculated Factors of Safety range from 1.1 to 2.5, indicating that a more detailed study is required.

Stability analysis of balanced boulders: methodology and case study

M. Muñiz-Menéndez; J. González-Gallego; J. Moreno-Robles; I. Pérez-Rey; L. R. Alejano; A. Riquelme

The presence of logan stones or pedestaled boulders is common in granitic environments. There are hundreds of examples of logan stones, many of them being next to inhabited areas, roads, main trails in natural parks and other zones where the fall of these structures could cause major damage. On the other hand, some of these boulders represent a touristic attraction in national parks—even some of them are frequently climbed—, and their preservation presents an economic interest.

In this paper, we present a methodology to analyse the stability of this kind of geological structures through its application to an iconic granitic boulder site in the northwest of Spain, the *Pena do Equilibrio* boulder. The stability of this boulder has previously been studied by some authors, using other techniques.

The 3D geometry of the boulder has been obtained by photogrammetry techniques and then, a 3D model has been created through different software processes. This model has been subsequently imported to a 3D distinct element software to perform the stability analysis, where the stability is calculated in both static and seismic conditions.

The methodology presented allows the easy and accurate study of the stability of geological structures with complex geometries, requiring a low time consumption and enabling the performance of advanced analysis.

The results of the current analysis have been compared with the analytical ones obtained from the same boulder that had been previously published. The similarity of the results obtained with the two methods validates our methodology and allows its use for future similar studies.

Synthetic porous rock manufacturing for hydrodynamic and petrophysical analyses

A. Muñoz-Ibáñez; A. Pérez-Quintiana; M. Herbón-Penabad; R. Juncosa-Rivera; J. Delgado-Martín

Different authors have used synthetic rocks to perform rock mechanics experiments or to assess petrophysical properties under well-known material conditions. In contrast with naturally cohesive materials, synthetic rocks provide with some opportunities to standardize mineralogy, grain size and morphology as well as the possibility to enhance certain rock features (e.g. anisotropy) useful to test or improve rock physical models. Typically, synthetic rocks are made of minerals grains bound together by a gluing agent that may be an organic adhesive (epoxy-like), cement or a nearly-

saturated silica solution. However, most of the available works reporting synthesis of artificial rocks in the literature do not present a comprehensive framework for, at least: a) How the manufacturing process was performed and what are the associated implications; b) the characterization of the physical and hydrodynamic properties of the final products; and c) an assessment about the consistency of rock-related results (*i.e.* homogeneity, reproducibility) from the artificial rocks.

In this contribution we present a methodology for the design, manufacturing and characterization of sandstone-like synthetic rocks. Sandstone-like plugs have been fabricated using homogeneous-size glass bead grains that have been compressed to a load limited by grain fragmentation (as recorded by simultaneous acoustic emissions). Sodium metasilicate and kaolinite were used as proto-binding agents. Cementation occurred as a result of direct chemical reactions and the submission of the samples to different thermal treatment paths. The plugs obtained have been tested in order to determine properties like density, porosity, specific surface, strength, and ultrasonic velocities (V_p and V_s) and their corresponding variabilities.

Temperature threshold of sedimentary rocks: a comparative study

M. E. Garrido; V. Martínez-Ibáñez; C. Hidalgo Signes; J. Company; R. Tomás

The mechanical behaviour of rocks is one of the main research topics in rocks mechanics. More specifically, there is a large body of scientific literature focused on the effect of high temperatures on rock properties. Recent fires in tunnels and historic monuments have revived interest in this topic. Most of these studies are focused on the evaluation of the variation of strength, deformability, and physical properties against temperature. Obviously, the general conclusion of these studies is that strength decreases, and deformability increases, as the target temperature increases. However, there is usually for each rock a temperature threshold (TT) at which these characteristics change sharply. The changes show different behaviour. This paper focuses on the study of a temperature threshold of a limestone from the eastern Spain and its behaviour after exposure to high temperature. Samples of this rocks are exposed to different target temperatures (*i.e.* 200, 400, 600

and 800 °C) and their properties such as porosity, density, unconfined compressive strength, and Young modulus are obtained. The studied limestones exhibit different TT and differing developments of these properties after heating. A comprehensive compilation of relevant topics is performed to compare the TT of different types of sedimentary rocks with that tested in this work.

The GIT tensile test: new characterization of the tensile strength in rock materials

C. Gonzalez-Nicieza; M. I. Alvarez-Fernandez; C. C. Garcia-Fernandez; J. R. Garcia-Menendez

Tensile strength is a key parameter in brittle materials which controls the design and stability in underground excavations, hydraulic failure analysis and blasting. However, establishing the tensile strength through direct methods is complicated due to the difficulty in its faithful reproduction in laboratory under uniaxial tensile stress conditions. For this reason, in the experimental practice, the tensile strength is calculated by using indirect test methods, highlighting the Brazilian test or diametral compression as the best known internationally.

In order to propose a new characterization technique of the tensile strength, this work describes a novel method called "The GIT tensile test", consisting in the use of a device designed by the DinRock Research Group of the University of Oviedo (Spain). The suggested method was applied in an acrylic homogeneous material (polymethylmethacrylate or PMMA) which uniaxial tensile strength is known, as well as a mortar characterized by brittle behaviour. In addition, both materials were also tested with the Brazilian tests for comparison purposes.

The results of the tensile strength achieved allow to establish the reliability of the suggested method, which avoids the generation of deformations and crushing in the vicinity of the load, because unlike the Brazilian test and other indirect methods, compression stresses are distant to the point where the failure is initiated. Therefore, the new test -which is easy to implement in any laboratory of Rock Mechanics- could complement other characterization methods under tension regimen.



Playa de Teno, Tenerife
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Resumen de otros artículos publicados por nuestros socios en 2020

Rockfall Hazard Assessment in Volcanic Regions Based on ISVS and IRVS Geomechanical Indices

Luis I. González de Vallejo, Luis E. Hernández-Gutiérrez, Ana Miranda and Mercedes Ferrer

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In volcanic regions, rockfalls represent a major hazard strongly conditioned by the geomechanical behaviour of volcanic materials, the geomorphological characteristics of the relief and the climatic conditions. Volcanic rocks possess very different properties to those of other lithological groups, presenting highly heterogeneous geomechanical behaviours. Nevertheless, they have received little research attention in the field of geological and geotechnical engineering.

To date, the application of geomechanical classifications to characterise and estimate volcanic slope stability has not yielded reliable results, indicating the need to establish specific criteria for these rocks. Consequently, we developed indices to estimate rockfall susceptibility, hazard and risk in volcanic slopes. The index of susceptibility for volcanic slopes (ISVS) is designed to estimate slope susceptibility to instability, which is related to the level of hazard, while the index of risk for volcanic slopes (IRVS) is designed to estimate the level of risk as a function of the potential damage or economic loss caused as a result of rockfalls on slopes. Both indices were developed in order to provide an easily applied procedure that facilitates the adoption of short-term preventive measures against rockfalls.

The indices were applied in Tenerife (Canary Islands), which presents exceptional conditions for analysing slope stability in volcanic rocks because of its mountainous orography with very steep slopes and a wide variety of materials. These conditions have frequently precipitated slope instability, causing significant damage to housing, beaches, roads and other infrastructures. After applying these indices to a number of slopes representative of the island's wide variety of geological, geomorphological and climatic conditions, the results obtained were compared with the actual behaviour of the slopes, determined from extensive rockfall inventory data and in situ geomechanical surveys.

Pure Mode I Fracture Toughness Determination in Rocks Using a Pseudo-Compact Tension (pCT) Test Approach

Andrea Muñoz-Ibañez, Jordi Delgado-Martin, Miguel Costas, Juan Rabuñal-Dopico, Jose Alvarellos-Iglesias, Jacobo Canal-Vila

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<https://doi.org/10.1007/s00603-020-02102-6>

Mode I fracture toughness (KIC) quantifies the ability of a material to withstand crack initiation and propagation due to tensile loads. The International Society for Rock Mechanics (ISRM) has proposed four suggested methods for determining KIC. However, these methods present some drawbacks such as insufficient post-peak control, complex sample preparation and considerable material requirements. Here we present an alternative approach, called the pseudo-compact tension (pCT) method, to measure KIC in rocks using disc-shaped specimens loaded in pure tension. The pCT specimen has favourable features such as a simple geometry, small sample volume and minimal machining requirement. The tensile load is transmitted to the specimen through two high-strength, high-stiffness steel jaws that fit into a U-shaped groove cut in the specimen. An additional thin straight notch is introduced to act as a stress concentrator. The crack propagates from the notch tip along the ligament plane, splitting the specimen into two halves. The effects of specimen size and notch length on KIC are determined by testing specimens 100, 50 and 38 mm in diameter with different notch length ratios ($0.1 \leq a/b \leq 0.4$). Tests were performed under ambient conditions and a slow loading rate (0.1 mm/min). Our results show that the pCT method is convenient for the assessment of KIC of both fragile and ductile rocks. The method offers good control even beyond the maximum load, making it possible to study the post-peak behaviour of the material.

Avances tecnológicos en la protección contra desprendimientos. Fundamentos para dimensionamiento de sistemas atenuadores

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Obras Urbanas 80 (España)

Los atenuadores son una solución de protección contra desprendimientos de rocas que combina una barrera flexible contra caída de rocas con una membrana de guiado de bloques o drapes. Hasta la fecha no existen soluciones formales para su dimensionamiento. En comparación con las barreras flexibles clásicas de protección contra caída de rocas, donde solo se considera la energía cinética translacional y el bloque se detiene por completo; los atenuadores presentan un desafío de diseño en el que deben

considerarse tanto la componente rotacional como traslacional de la velocidad del bloque que cae. Además, los sistemas atenuadores están concebidos para detener el bloque, su función es modificar la trayectoria y moderar la velocidad. Para desarrollar un concepto de dimensionamiento que aborde estas dinámicas, es importante comprender completamente el proceso de atenuación. Un programa conjunto entre Willis & Norrish Rock Engineers, Ltd. (Canadá), Geobrugg North America, LLC, y Geobrugg AG (Suiza) ha investigado de forma detallada este proceso. La carga en el sistema, los procesos de atenuación y la importancia del componente rotacional, se analizaron en una serie de ensayos a escala natural durante un período de tres años, en la cantera de Hope BC en la Columbia Británica (Canadá). Esta contribución, proporciona información sobre el análisis de los mecanismos de carga que actúan sobre el sistema atenuador, durante el impacto del bloque. La dinámica del movimiento del bloque se compara entre los resultados extraídos de los sensores (acelerómetro y giroscopio) integrados en los bloques de ensayo, el análisis de video de alta velocidad y las simulaciones de la caída mediante software especializado. Estos análisis proporcionan los fundamentos con los que se ha creado una novedosa herramienta de dimensionamiento.

Sistemas novedosos. Galerías dinámicas con efecto autolimpieza compuestas por redes de anillos de alambre de alta resistencia

Roberto J. LUIS FONSECA, Corinna WENDELER,

Ingeopres 277 (España)

Sin duda el efecto del cambio climático cada día se hace sentir más en nuestra vida cotidiana, las estadísticas del último decenio señalan que estamos ante una reducción en los períodos de retorno o incremento en la probabilidad de ocurrencia de fenómenos catastróficos, que en general arrastran importantes secuelas, luego la demanda de medidas de seguridad se hace cada vez mayor. En el sector específico de riesgos geológicos se trata de mitigar eventos que incluyen: desprendimientos de rocas, deslizamientos de tierras, avalanchas de nieve y flujos de detritos. De forma concreta, este tipo de fenómenos se ha incrementado y por lo tanto todo indica que la demanda de innovación y seguridad de los sistemas seguirá creciendo. En regiones montañosas, las galerías dinámicas flexibles con efecto autolimpieza, son una alternativa económica y respetuosa con el medio ambiente, respecto a los cobertizos de hormigón como protección contra desprendimientos de rocas. Esta solución puede actuar de manera análoga a una cortina, atenuando y encauzando la energía cinética del impacto de la roca. El sistema está diseñado para autolimpiarse, en caso de impactos cuya energía cinética esté por debajo de un cierto umbral, se consigue un efecto de trampolín y los bloques son desviados por el sistema, lo cual hace mínimos los costes de mantenimiento.

Rockburst simulation using dynamic tests on the support system

Rico Brändle, Roberto J. Luis Fonseca, Germán Fisher,

JMiner (Chile)

Resumen:

Ground support for dynamic conditions must be able to withstand the associated loads and deformations and the support scheme must work as a system. In order to prove the suitability of such support systems with high-tensile steel mesh and bolts and to analyze the bearing behavior of them, a large-scale test setup was commissioned in Walenstadt, Switzerland. On this test rig it is possible to apply large energies on variable ground support systems with variable bolt patterns and meshes with a total support area of $3.6 \times 3.6\text{ m}$ in a full-scale way. The test site is instrumented by load cells, high-speed video analysis and accelerometers. In this paper the analysis of the load cells, the accelerometers and the high-speed video cameras is given, and results of system tests are discussed.

Soluciones flexibles de protección contra flujos de detritos en comparación con los métodos tradicionales

Roberto J. Luis Fonseca, Rolando Romero Rojas, Gabriel Von Rickenbach

Rumbo Minero (Perú)

Combinadas, la erosión hídrica y eólica son responsables de aproximadamente el 84% de la extensión global de tierras degradadas, lo que hace que la erosión excesiva sea uno de los problemas ambientales más importantes en todo el mundo. Cada año, alrededor de 75 mil millones de toneladas de suelo se erosionan de la tierra. La presencia de agua como parte de estos fenómenos, provoca que se desencadenen corrientes de arrastre de materiales y sedimentos que en ocasiones provocan pérdidas en vidas humanas e infraestructuras. El flujo de detritos (huaico en el Perú) es una combinación de fenómenos naturales que se dan como consecuencia de inundaciones u ocurrencia de fenómenos meteorológicos generalmente con períodos de retorno altos, suelen ser fenómenos excepcionales, aunque en algunos lugares se dan con relativa frecuencia. Consiste básicamente en el arrastre por un torrente de agua de materiales sueltos, granulares y tierra o lodo, restos de vegetación y en ocasiones troncos de árboles, a través de los cauces naturales del terreno. Al igual que los desprendimientos de rocas el flujo de detritos actúa de forma dinámica, pero a diferencia del primero el impacto no es puntual.

Shallow landslides controlled by flexible barriers composed of high-strength steel nets

Roberto J. Luis Fonseca, Gonzalo Díaz Trillo

SCG-XIII International Symposium on Landslides. Cartagena, Colombia

On steep slopes, several different gravity driven hazards (shallow landslide, rockfall, snow slides) threaten the safety of people and infrastructure. Saturated layers of soil can

form into shallow landslides and flow at relatively high speeds of up to 10 m/s (35 km/h). Depending on the speed and volume of the displaced material, shallow landslides can have a destructive impact, disrupting traffic routes and cause major damage to buildings. Considering global climate change as a risk factor, with meteorologists predicting that the likelihood of extreme rainfall events will rise across the world, the potential to trigger shallow landslides is also increasing. Therefore, suitable mitigation measures need to be designed to protect lives and infrastructure against shallow landslides. Conventional protective measures consist of structures to divert the landslide – dams or reinforced walls – require a large amount of material and labor for construction. Flexible shallow landslide barriers are alternative protection systems that have been proven to retain mudslides and shallow landslides, even in the event of multiple impacts. The barriers can be installed with a low outlay of material and man-hours, reducing costs and construction time. In addition, on steep slopes both shallow landslide and rockfall hazards occur in similar terrain and need to be considered in combination. In this contribution we discuss the challenges in designing protection measures that can cope with both shallow landslides and rockfalls, each one characterized by different load cases. Shallow landslides impact with spreading pressures that load gradually, while rockfalls impact punctually with high velocities. We discuss the findings of a few full-scale experiments investigating different load cases; a finite element simulation software FARO used in the design of flexible wire protection systems will be presented.

Results of large-scale testing of high-tensile steel meshes and soil nails for ground surface support and validation of modelling software

Roberto J. Luis Fonseca, Gonzalo Díaz Trillos.

SCG-XIII International Symposium on Landslides.
Cartagena, Colombia

The stability of newly cut or natural slopes is an important issue of geotechnical engineering. Regardless of the scale of the project, the design and the execution must assure maintenance-free and, more importantly, safe utilisation of the slope. Nowadays, a geotechnical engineer can choose from several different, available slope stabilisation methods. Nevertheless, one of the most frequently chosen methods is soil nailing in combination with flexible facing (Luis-Fonseca, 2010). In this configuration, the soil nails are designed to stabilise deep-seated instabilities, while localised instabilities must be stabilised by the strong flexible facing, typically represented by high-tensile steel wire mesh. In order to assure proper slope stabilisation, the soil nails and the flexible facing must act as one integrated system. Such a system has been lately tested in large scale within this R&D project supported by the Swiss Institute for Technology and Innovation (CTI). The large-scale setup, widely described in Caña et al (2013), consisted of an inclinable large box ($12 \times 10 \times 1.2$ m), soil material, nails, high-tensile steel wire mesh, steel plates (linking nail heads and mesh), connection clips (linking two sheets of mesh) and boundary ropes. The entire setup was lifted on one side to imitate the slope inclination. While lifting the box up several measurements were taken (e.g. tension forces and

bending in the nails or mesh displacement). In total 31 large-scale tests were conducted, at first to check the testing setup and later to test the interactions of the nails and high-tensile steel mesh, which were put together in different arrangement and configurations. The most important testing variables were soil material, nail pattern, type of steel wire mesh and connection plate. The main aim of this paper is to present the analysis of the performance of three meshes composed of 2, 3 and 4 mm diameter wire, tested in comparable conditions (the same soil conditions, nail pattern and connection plate). The purpose of this analysis was to show the distinction in bearing capacity and range of deformation of meshes produced from the same steel high quality but of different wire diameter. This analysis was also used for the purpose of validation of already existing dimensioning concept based on lab tests

Discrete numerical analyses of grain size influence on the fracture of notched rock beams

J. Justo, H. Konietzky, J. Castro

Computers and Geotechnics

This paper studies the influence of the grain size and the notch effect on the fracture assessment of U-shaped notched rock beams through the variation of the apparent fracture toughness. The research is based on an exhaustive campaign that comprises numerical simulations of 300 four-point bending tests, 30 simple compression tests and 60 tensile splitting (Brazilian) tests. Non-porous, isotropic ideal and equivalent rocks with 5 different uniform grain sizes are modelled using the distinct element method, where the rocks are modelled as a discontinuous material, defining explicitly the grains and the boundary conditions. Several notch radii are simulated and the corresponding variation in the apparent fracture toughness is observed. This notch effect is interpreted using the Theory of Critical Distances (TCD), which uses a material intrinsic property called the critical distance (L) to evaluate the stress field around the notch tip. The paper shows the variation of the fundamental rock properties with the grain size, the applicability of the TCD to evaluate the notch effect and the correlation between the critical distance and the grain size.

Notch effect and fracture load predictions of rock beams at different temperatures using the theory of critical distances

J. Justo, J. Castro, S. Cicero

International Journal of Rock Mechanics and Mining Sciences

This work aims to analyse the fracture behaviour of rocks with U-shaped notches subjected to mode I loading and to different temperature conditions. To this end, the so called Theory of Critical Distances (TCD) is applied and four different types of isotropic rocks are studied: a Floresta sandstone, a Moleano limestone, a Macael marble and a

Carrara marble. This study attempts to extend a previous work of the authors where the TCD was successfully applied to U-notched components subjected to mode I loading conditions at room temperature. In this case, the effect of temperature is considered as a new variable.

The research comprises, in total, more than 790 four-point bending tests and 144 tensile splitting (Brazilian) tests. The latter include 6 disc-shaped specimens for each rock and temperature (6 different temperatures), while the four-point bending tests consist of at least 6 SENB specimens for each rock, notch radius (8 different notch radii varying from 0.15 mm to 15 mm) and temperature (4 different temperatures) combination. The temperatures considered in this study vary from room temperature up to 250°C, which is a common range in geothermal applications.

Temperature has proven to be a significant parameter when analysing the fracture behaviour of the four selected rocks. Its influence on the tensile strength and fracture toughness of the rocks is clear and reveals common patterns. However, no apparent tendencies are shown on the influence of temperature on the critical distance (L). Likewise, the application of the TCD has led to relatively accurate fracture predictions and notch effect analyses at different temperature conditions.

Voronoi based discrete element analyses to assess the influence of the grain size on the apparent fracture toughness of notched rock specimens

J. Justo, J. Castro, H. Konietzky

54th US Rock Mechanics/Geomechanics Symposium (ARMA2020)

The fracture toughness reflects the rock resistance to crack propagation, and therefore represents an important parameter for rock fracture assessments. From a strict point of view, the real fracture toughness (K_{IC}) corresponds to a cracked situation in which the notch radius is theoretically equal to zero. However, most of the defects in rocks have a finite radius and, therefore, should be studied as notch-type defects. Here, the notch effect is numerically studied through the influence of the grain size on the apparent fracture toughness (K_{IN}). To this end, several four-point bending tests with different U-shaped notch radii and mean grain sizes have been simulated using the Discrete Element Method. In order to represent the grains of the rocks, the Voronoi tessellation is used to create randomly sized and distributed polygonal blocks. These Voronoi polygons are defined by an average edge length of 1, 2 and 3 mm. The performed numerical analyses and the interpretation of the results show a clear notch effect, as the apparent fracture toughness (K_{IN}) increases with notch. Finally, the obtained stress fields at the bisector of the notch tip have been compared to those obtained from the traditional Finite Element Method.

Distinct-Element Method Simulations of Rock-Socketed Piles: Estimation of Side Shear Resistance Considering Socket Roughness

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Journal of Geotechnical and Geoenvironmental Engineering
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Rock-socketed piles are foundational elements designed to transmit large concentrated loads to stronger materials located at greater depths. The rock-socket side shear resistance is commonly estimated using empirical criteria as a percentage of the rock or concrete uniaxial compressive strength. However, this approach neglects the influence of other important aspects, such as the roughness of the pile-socket interface. In this work, numerical discrete-element models of rock-socketed piles with different degrees of socket roughness are employed to estimate the influence of the socket roughness on the load-settlement response and on the side shear resistance. The numerical simulation results are compared with predictions obtained using empirical correlations based on load test results and proposed by other authors. Results indicate that the discrete-element method is suitable to reproduce rock-socket pile behavior considering socket roughness; they also suggest that sockets drilled with standard tools in soft to medium rock tend to be relatively smooth unless artificially roughened with special tools and that damage to the interface asperities becomes more relevant after socket settlement of about 1% of the socket diameter, especially for rougher piles.

Correcting indirect strain measurements in laboratory uniaxial compressive testing at various scales

Alejano, L.R., Arzúa, J., Estévez-Ventosa, X., Suikkanen, J

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10.1007/s10064-020-01853-4

Various devices can directly or indirectly measure strain and record the deformational response of rock materials in uniaxial compressive strength tests. Strain gauges glued to specimens directly measure electrical resistance, while displacement sensors, typically linear variable differential transformers (LVDTs), indirectly measure linear displacements. However, no guidance is available regarding how to position the LVDTs to accurately measure axial or radial strain. A common practice is to measure axial strain with displacement sensors on the basis of the reduction in span between steel platens in relation to specimen height. If the deformational response for axial strain measured using strain gauges and displacement sensors is compared, however, it may be that neither maximum axial strain nor elastic constants are the same. This paper describes an approach to correcting platen-to-platen displacement measurements based on energy calculations at different scales in Olkiluoto gneissic rock specimens, with control specimens tested by combining strain gauge and displacement sensor measurements. It is suggested that the approach may be adaptable to other rocks. © 2020, Springer-Verlag GmbH Germany, part of Springer Nature.

Particle flow code simulation of intact and fissured granitic rock samples

Castro-Filgueira, U., Alejano, L.R., Mas-Ivars, D.

Journal of Rock Mechanics and Geotechnical Engineering, 12 (5), pp. 960-974.

DOI: 10.1016/j.jrmge.2020.01.005

This study presents a calibration process of three-dimensional particle flow code (PFC3D) simulation of intact and fissured granite samples. First, laboratory stress-strain response from triaxial testing of intact and fissured granite samples is recalled. Then, PFC3D is introduced, with focus on the bonded particle models (BPM). After that, we present previous studies where intact rock is simulated by means of flat-joint approaches, and how improved accuracy was gained with the help of parametric studies. Then, models of the pre-fissured rock specimens were generated, including modeled fissures in the form of “smooth joint” type contacts. Finally, triaxial testing simulations of 1 + 2 and 2 + 3 jointed rock specimens were performed. Results show that both elastic behavior and the peak strength levels are closely matched, without any additional fine tuning of micro-mechanical parameters. Concerning the post-failure behavior, models reproduce the trends of decreasing dilation with increasing confinement and plasticity. However, the dilation values simulated are larger than those observed in practice. This is attributed to the difficulty in modeling some phenomena of fissured rock behaviors, such as rock piece corner crushing with dust production and interactions between newly formed shear bands or axial splitting cracks with pre-existing joints. © 2020 Institute of Rock and Soil Mechanics, Chinese Academy of Sciences

Influence of Microroughness on the Frictional Behavior and Wear Response of Planar Saw-Cut Rock Surfaces

Pérez-Rey, I., Bastante, F.G., Alejano, L.R., Mas-Ivars, D.

International Journal of Geomechanics, 20 (8), art. no. 04020118, .

DOI: 10.1061/(ASCE)GM.1943-5622.0001742

Saw-cut rock surfaces, classically utilized to estimate basic friction angle of discontinuities by means of tilt test and other procedures, may seem planar to the naked eye. Nevertheless, they actually present roughness at a micrometric scale. Aiming at characterizing some of these saw-cut rock surfaces and assessing the possible implications between their microscale topography and the resulting tribological behavior, the authors of this study resorted to the 3D focus-variation technique to analyze different surface-texture parameters. Tilt tests were carried out on specimens cut on three rock types, and the involved sliding surfaces were evaluated at a microscale for different testing stages (prior to any test and after two series of repeated tests). An apparently logical inverse correlation between repeated testing and friction angle has been observed, more marked for the smoother surfaces. Higher roughness at the scale of the analysis tends to produce lower friction-angle values, as otherwise observed for mismatched

natural rock surfaces. In addition, saw-cut rock surfaces present systematically negative skewness and high values of kurtosis for their height distributions, indicating the occurrence of narrow and deep pits or valleys. Directional hybrid parameters and, in particular, the root mean square (RMS) of the gradient of the surface in the direction of sliding correlates rather well with the measured sliding angle. The authors concluded that the 3D focus-variation technique represents a powerful tool to assess surface-texture parameters of saw-cut rock surfaces, in addition to being useful for understanding some features of the tribological, or wear and frictional, behavior of these type of surfaces.

Evaluation of strength and deformability of soft sedimentary rocks in dry and saturated conditions through needle penetration and point load tests: a comparative study

Rabat, Á., Cano, M., Tomás, R., Tamayo, Á.E., Alejano, L.R.

Rock Mechanics and Rock Engineering, 53 (6), pp. 2707-2726.

DOI: 10.1007/s00603-020-02067-6

The preparation of standardized soft rock specimens to perform unconfined compressive strength (UCS) tests is typically difficult, expensive and time-consuming. Needle penetration test (NPT) was originally developed in Japan as an alternative for the indirect estimation of UCS of soft rocks. The needle penetrometer is a simple, portable and non-destructive testing device that measures applied load and penetration depth for the rock to calculate the needle penetration index (NPI). A complimentary, portable and widely used destructive test is the point load test (PLT), which measures regular and irregular specimens by the application of a concentrated load using two coaxial conical platens that yield the point load strength index (IS(50)). We investigated and compared the NPT and PLT in terms of measuring changes induced by water saturation and obtaining UCS and the static Young's modulus (Est) for dry and saturated soft sedimentary rocks. The results point to significant correlation functions from which to infer UCS and Est in terms of NPI and IS(50) in dry and saturated soft rocks. Furthermore, both NPT and PLT are suitable tests for evaluating changes in strength and deformability induced by water saturation. We also found a good correlation between the NPI and Is(50).

Reliability-based design for debris flow barriers

Vagnon, F., Ferrero, A.M., Alejano, L.R.

Landslides, 17 (1), pp. 49-59.

DOI: 10.1007/s10346-019-01268-7

ABSTRACT: In the European Union since 2010, the design of any type of structures must comply with EN-1997 Geotechnical Design (CEN 2004) (EC7) referring to

engineering projects in the rock mechanics field. However, the design of debris flow countermeasures in compliance with EC7 requirements is not feasible: EC7 uses partial safety factors for design calculations, but safety factors are not provided for phenomena such as debris flows and rock falls. Consequently, how EC7 can be applied to the design of debris flow barriers is not clear, although the basic philosophy of reliability-based design (RBD), as defined in EN1990 (CEN 2002) and applicable to geotechnical applications, may be a suitable approach. However, there is insufficient understanding of interactions between debris flows and structures to support RBD application to debris flow barrier design, as full-scale experimental data are very limited and difficult to obtain. Laboratory data are available but they are governed by scale effects that limit their usefulness for full-scale problems. The article describes an analysis, using the first-order reliability method (FORM), of two different datasets, one obtained through laboratory experiments and the other reflecting historical debris flow events in the Jiangjia Ravine (China). Statistical analysis of laboratory data enabled a definition of the statistical distributions of the parameters that primarily influence debris flow and barrier interactions. These statistical distributions were then compared to the field data to explore the links between flume experiments and full-scale problems. This paper reports a first attempt to apply RBD to debris flow countermeasures, showing how the choice of the target probability of failure influences the barrier design resistance value. An analysis of the factors governing debris flows highlights the applicability and limitations of EN1990 and EN1997 in the design of these rock engineering structures.

Proyecto de estructuras geotécnicas de acuerdo al futuro eurocódigo 7

José Estaire, Andrew J. Bond

Revista Geotecnia, nº 149 – July 2020 (pp. 45-65)
DOI: 10.24849/j.geot.2020.149.03

RESUMEN – Este trabajo constituye una guía breve para la elaboración de los proyectos de las estructuras geotécnicas para cumplir los requerimientos y recomendaciones de seguridad, nivel de servicio, robustez y durabilidad a los que se deben ajustar dichos proyectos, de acuerdo a lo indicado en los futuros Eurocódigo 0 y Eurocódigo 7 que previsiblemente estarán aprobados alrededor de 2025.

La guía se basa en unos diagramas de flujo para cada una de las cinco tareas que comprende el proyecto de una estructura geotécnica: a) Procedimientos de fiabilidad, b) Modelización del terreno, c) Verificaciones de proyecto, d) Implementación del proyecto durante la ejecución y e) Realización de informes.

Dichos diagramas permiten explicar los procedimientos para a) determinar la Categoría Geotécnica de la estructura geotécnica en estudio, b) desarrollar el Modelo del Terreno y el Modelo del Proyecto Geotécnico, c) verificar los estados límites últimos y de servicio, mediante la aplicación de los factores parciales indicados en los diferentes Casos de Diseño, d) realizar diferentes planes que aseguren la seguridad y calidad de las estructuras geotécnicas durante su ejecución y e) elaborar diferentes informes durante el proyecto y ejecución de la estructura geotécnica.

Ensayos de corte en laboratorio para determinar la resistencia residual de arcillas sobreconsolidadas

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RESUMEN – Durante los deslizamientos en suelos arcillosos sobreconsolidados, la resistencia que realmente actúa en discontinuidades, zonas de cizalla, fisuras, y zonas de reorientación de arcillas es la resistencia al corte residual. En este artículo se comparan los valores de parámetros resistentes obtenidos mediante el análisis retrospectivo de un deslizamiento, considerado como el valor más fiable a lo largo del plano de rotura, y los obtenidos mediante diferentes ensayos de resistencia al corte en laboratorio. De este modo, se determina el ensayo de laboratorio que proporciona los valores de resistencia más cercanos a los presentes en el momento de la rotura en campo. Por otro lado, gracias a las elevadas tensiones efectivas aplicadas en los ensayos se incluye un nuevo intervalo de índices de fragilidad de la formación de estudio. Adicionalmente, se propone un procedimiento de ensayo de corte anular alternativo, que combina los métodos propuestos en las normativas europea (EN ISO 17892-10:2018), británica (BS 1377-7:1990) y norteamericana (ASTM D6467-06a:2006).

A methodology to estimate permeability in porous and fissured rock specimens at laboratory scale

Estévez-Ventosa, X., González-Molano, N.A., Blázquez-Pascual, V., Alvarellos, J., Alejano, L.R.

Archives of Mining Sciences, 65 (4), pp. 821-833.

The correct management of underground works, petroleum and gas reservoirs and geothermal applications relies on the hydromechanical behaviour of rock masses. We describe a laboratory approach to measuring permeability for different types of rock specimens. A laboratory system was designed and set up using rock mechanics equipment (a servo-controlled hydraulic press, a Hoek cell, a pump for injecting water and a scale for measuring the volume of water flow). To verify the validity of the permeability measurements, tests were carried out on a reference porous rock (Corvío sandstone), with results showing good agreement with those published in the literature. Tests were subsequently carried out on artificially fissured granite specimens with different joint patterns, submitted to various confinement stresses up to 20 MPa. Results showed good agreement with traditional Klinkenberg test results. Other tests done with artificially fissured specimens are described for demonstrative purposes. © 2020. The Author(s).

Evaluation of mechanical weakening of calcarenous building stones due to

environmental relative humidity using the vapour equilibrium technique.

Rabat, Á.; Tomás, R.; Cano, M.

Engineering Geology. 278, pp. 1 -19. 2020. ISSN 0013-7952

Previous studies have evaluated the water-weakening effect of rock materials after immersion in water during different periods of time. However, the water transference between the environment and the building stones frequently occurs in vapour form when changes in the relative humidity of the air involve little variations in moisture content of stones. In this sense, the novelty of this work lies in assessing the impact of the environmental relative humidity (RH) on Unconfined Compressive Strength (UCS), Young's modulus (Est), Brazilian Tensile Strength (BTS) and Point Load Strength Index (Is(50)) of three calcarenous building stones. To this aim, calcarenous specimens were exposed to five different environments with RH values ranging from 10 to 93% which were devised in laboratory through a novel modified Vapour Equilibrium Technique (VET) by using water-glycerol solutions at different concentrations and then, they were mechanically tested. The results indicated that, despite the water content (w) and the degree of saturation (S_r) inside the pore network of calcarenous stones were relatively small for all RH environments ($w=0.03-1.79\%$ and $S_r=0.2-35.6\%$), important reductions of UCS (28.2-34.7%), Est (20.0-31.3%), BTS (17.0-41.3%) and Is(50) (23.9-37.6%) were found when the RH varied from 10 to 93%. Furthermore, negative linear relationships were established between the values of the mechanical properties and the environmental RH while negative tri-parametric exponential functions were proposed between the mechanical parameters and w . In addition, the mechanisms involved in the observed behaviour were discussed and relationships between the different mechanical properties were also proposed.

Impact of water on peak and residual shear strength parameters and triaxial deformability of high-porosity building calcarenous stones: Interconnection with their physical and petrological characteristics.

Rabat, Á.; Tomás, R.; Cano, M.; Miranda, T.

Construction and Building Materials. 262, 2020.
ISSN 0950-0618

Several studies have found that water can cause substantial reductions of mechanical properties of building stones such as unconfined compressive strength, tangent Young's modulus or tensile strength. However, the influence of water content on shear strength parameters, triaxial compressive strength and modulus of elasticity under different confining pressures has been scarcely examined. For this reason, the present paper assesses the impact of water on peak and residual compressive strength and tangent Young's modulus of three porous building geomaterials widely used in civil and architectural constructions under different confining

pressure through triaxial compressive tests. Furthermore, the corresponding peak and residual shear strength parameters computed from Mohr-Coulomb (c and ϕ) and from Hoek-Brown (σ_{ci} and m_i) failure criteria are obtained under dry and saturated conditions. Complementary physical and petrological analyses are performed in order to understand the main causes of the effect of water observed in these rock materials. The results indicate that water causes significant reductions of peak and residual compressive strength and tangent Young's modulus in the tested porous building stones for all the different applied confining pressures. Additionally, important changes of peak and residual shear strength parameters (c , ϕ , σ_{ci} and m_i) are exhibited by the studied stones when become saturated. This could be related to physicochemical changes such as the hydrolysis of quartz and silicates in crack tip region inducing subcritical crack growth (stress corrosion), the decrease of the cement quality and the deterioration of the intergranular bonds due to the dispersion or dissolution of some minerals (calcite or chlorite) and the formation of microcracks caused by the swelling of the clay minerals present in these materials when they come into contact with water.

Evaluation of Strength and Deformability of Soft Sedimentary Rocks in Dry and Saturated Conditions Through Needle Penetration and Point Load Tests: A Comparative Study

Rabat, Á.; Cano, M.; Tomás, R.; Tamayo, Á.E.; Alejano, L.R.

Rock Mechanics and Rock Engineering. 53, pp. 2707 - 2726. 2020. ISSN 0723-2632

The preparation of standardized soft rock specimens to perform unconfined compressive strength (UCS) tests is typically difficult, expensive and time-consuming. Needle Penetration Test (NPT) was originally developed in Japan as an alternative for the indirect estimation of UCS of soft rocks. The needle penetrometer is a simple, portable and non-destructive testing device that measures applied load and penetration depth for the rock to calculate the needle penetration index (NPI). A complementary, portable and widely used destructive test is the point load test (PLT), which measures regular and irregular specimens by the application of a concentrated load using two coaxial conical platens that yield the point load strength index (IS(50)). We investigated and compared the NPT and PLT in terms of measuring changes induced by water saturation and obtaining UCS and the static Young's modulus (Est) for dry and saturated soft sedimentary rocks. The results point to significant correlation functions from which to infer UCS and Est in terms of NPI and IS(50) in dry and saturated soft rocks. Furthermore, both NPT and PLT are suitable tests for evaluating changes in strength and deformability induced by water saturation. We also found a good correlation between the NPI and Is(50).

Effect of water saturation on strength and deformability of building calcarenous

stones: Correlations with their physical properties

Rabat, Á.; Cano, M.; Tomás, R.

Construction and Building Materials. 232, pp. 1 - 15. 2020.
ISSN 0950-0618

Stone construction elements are frequently in moist environments or in direct contact with water. Design and test standards have traditionally ignored the water impact on rock materials. However, several studies have shown that moisture can cause drastic strength reductions and deformability increase in some sedimentary rocks. For that reason, the main objectives of this work are: a) to quantify and understand the influence of water saturation on strength and deformability of four porous calcarenous building stones widely used in SE Spain; b) to establish correlations between physical and mechanical properties of these rock materials in dry and saturated states and c) to compare the results with previous findings. The results showed a very significant reduction of mechanical properties such as unconfined compressive strength, Young's modulus and point load strength index when these stones undergo saturation. In addition, significant correlations between physical properties (density, porosity, P wave velocity and dynamic elastic parameters) and the mentioned mechanical properties were established in dry and saturated conditions. Additionally, relationships among the mechanical properties of stones in both states are also proposed.

Temperature-Induced Explosive Behaviour and Thermo-Chemical Damage on Pyrite-Bearing Limestones: Causes and Mechanisms

Víctor Martínez-Ibáñez, David Benavente, Carlos Hidalgo Signes, María Elvira Garrido, Roberto Tomás

Rock Mechanics and Rock Engineering.
<https://doi.org/10.1007/s00603-020-02278-x>

In this investigation, two different varieties of 'Prada' limestones were studied: a dark grey texture, bearing quartz, clay minerals, organic matter and pyrites, and a light grey texture with little or no presence of such components. We have observed two effects of different intensity when heating the dark texture from 400° C: i) the explosion of certain samples and ii) greater thermal damage than in the light grey texture. Chemical and mineralogical composition, texture, microstructure, and physical properties (i.e. colour, open porosity, P and S-wave velocity) have been evaluated at temperatures of 105, 300, 400 and 500° C in order to identify differences between textures. The violence of the explosive events was clear and cannot be confounded with ordinary splitting and cracking on thermally-treated rocks: exploded samples underwent a total loss of integrity, displacing and overturning the surrounding samples, and embedding fragments in the walls of the furnace, whose impacts were clearly heard in the laboratory. Thermogravimetric results allowed the identification of a process of oxidation of pyrites releasing SO₂ from 400° C. This process jointly with the presence of micro-fissures in the dark texture, would cause a dramatic increase in pore-

pressure, leading to a rapid growth and coalescence of microcracks that leads to a process of catastrophic decay in rock integrity. In addition to the explosive events, average ultrasound velocities and open porosity showed a greater variation in the dark grey texture from 400° C. That results also points towards a significant contribution of oxidation of pyrites on the thermo-chemical damage of the rock, among other factors such as the pre-existence of micro-fissures and the thermal expansion coefficient mismatch between minerals. Implications in underground infrastructure and mining engineering works are critical, as the explosive potential of pyrite-bearing limestones bear risk for mass fracturing and dramatic strength decay from 400° C. Moreover, SO₂ released has harmful effects on health of people and the potential to form acid compounds that corrode materials, shortening their durability and increasing maintenance costs.

Analysis and modeling of the combined effects of hydrological factors on a reservoir bank slope in the Three Gorges Reservoir area, China.

Huang, D. Luo, S., Zhonga, Z., Gu, D., Song, Y., Tomás, R.

Engineering Geology, 279, 105858.
<https://www.sciencedirect.com/science/article/abs/pii/S0013795220317555>

More than 5000 landslides have been identified in the Three Gorges Reservoir (TGR) area since the impoundment in 2003, which posed great threats to the residential houses, transportation on the Yangtze, and dam stability. This paper focuses on the evaluation of the coupled influence of rainfall and reservoir water on deformation characteristics and failure evolution of the Outang landslide (in China) based on field investigations, a statistical Pearson cross-correlation coefficient analysis, multi-technique monitoring data, and a numerical model. This instability is a reactivated ancient landslide with a volume of approximately 90 Mm³ located in the Three Gorges Reservoir. The slope behavior is featured with a short period of fast displacement and a relatively long period of semi-constant displacement rates per hydrological year, and displacements velocities quicken gradually upslope. Rainfall and reservoir water level are the main triggering factors of slope movement existing in the upper and the lower parts of the landslide, respectively. Based on the numerical results, the failure evolution of this landslide is a compounded push-retrogression-type failure process involving: a) a first rupture at the toe caused by the reservoir water level that will rapidly mobilize a second and subsequent collapses upwards (retrogression type); and b) the rock mass at the upper part will be pushed out and failed downslope (push type) due to precipitation. These results provide a comprehensive analysis of the Outang landslide, which is critical for its management, as well as for disaster prevention and mitigation of analogous reservoir-induced landslides.

Evaluación de la estabilidad de taludes rocosos a partir de nubes de puntos 3D obtenidas con un vehículo aéreo no tripulado

R. Tomás, A. Riquelme, M. Cano, J.L. Pastor, J.I. Pagán, J.L. Asensio, M. Ruffo

Revista de Teledetección. 2020, 55: 1-15.
doi:10.4995/raet.2020.13168

En este trabajo se describe una metodología propuesta para la identificación semiautomática de discontinuidades y el posterior análisis cinemático y de estabilidad a través de su aplicación a una trinchera excavada en roca de una línea de ferrocarril. La adquisición de imágenes se ha llevado a cabo mediante un vehículo aéreo no tripulado de seis motores para su posterior restitución fotogramétrica a través de la técnica digital Structure from Motion (SfM) mediante el programa Agisoft Metashape que proporciona una nube de puntos 3D. A partir de esta nube de puntos, se han identificado cuatro familias de discontinuidades (J1, J2, J3 y J4) que afectan al talud haciendo uso del programa de código abierto Discontinuity Set Extractor (DSE). Finalmente, se han llevado a cabo análisis cinemáticos y de estabilidad de las posibles roturas de bloques a favor de las discontinuidades identificadas en el talud. Los resultados muestran tres potenciales roturas por cuña y una plana que han sido validadas cualitativamente mediante el análisis de la geometría de las nubes de puntos.

Cerchar Abrasivity Index Estimation of Andesitic Rocks in Ecuador from Petrographical Properties Using Artificial Neural Networks.

Garzón-Roca, Julio; Torrijo, F.J.; Alonso-Pandavene, Olegario Martín; S.Alija.

International Journal of Geomechanics, 5 (2).
DOI: 1 - 9. 10.1061/(ASCE)GM.1943-5622.0001632

Abstract 1: Rock abrasivity is the main factor that causes erosion of excavation tools and is usually quantified by the Cerchar Abrasivity Index (CAI). Although Cerchar abrasivity tests are easy to perform, they are time consuming and require a relatively high volume of rock samples. Having good correlations of CAI values and other faster and simpler tests is therefore of great interest, since it results in time and budget savings when controlling excavating tool wear. Based on the results of 73 andesitic rock samples coming from the central area of Ecuador, this paper presents a series of artificial neural networks developed to find a good estimation of CAI values of andesitic rocks from their petrographical properties. The network showing the best performance (R^2 equal to 97%) is identified and a detailed process to estimate CAI value using the network developed is described.

Identification and mitigation of sinkhole hazards in an evaporite karst area (Perdiguera, Spain).

Torrijo, F.J.; R. Fuentes ; Boix, Alberto; Brachhi, P.

International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences (Online), XLIV (1), 707 - 712.

DOI: 10.5194/isprs-archives-XLIV-M-1-2020-707-2020

Sinkhole risks are becoming particularly severe in urban areas that lack careful planning and where karst depressions are frequently filled and developed. Sinkholes frequently have a higher probability of occurrence and a bigger genetic diversity in evaporite rocks than in carbonate rocks. This is because evaporites rocks (halite, gypsum, etc) have a higher solubility. Subsidence damage resulting from this dissolution generates considerable losses at the world. To contract with these risks, is needed the identification, investigation, prediction, and mitigation of sinkholes. Corrective measures might be applied to reduce the subsidence processes. A more practical solution for safe development is to reduce the vulnerability of the structures by using subsidence-proof designs. Therefore, this case study is located in the town of Perdiguera (Zaragoza, Spain), within the Ebro Basin. This town is affected by subsidence problems, which are associated with the dissolution of gypsiferous silts that generate sinking. These sinkholes are affecting the buildings threatening its structural integrity.

Applying Statistical Analysis and Machine Learning for Modeling the UCS from P-Wave Velocity, Density and Porosity on Dry Travertine

Saldaña, M.; González, J.; Pérez-Rey, I.; Jeldres, M.; Toro, N.

Appl. Sci. 10(13), 4565
<https://doi.org/10.3390/app10134565>

In the rock mechanics and rock engineering field, the strength parameter considered to characterize the rock is the uniaxial compressive strength (UCS). It is usually determined in the laboratory through a few statistically representative numbers of specimens, with a recommended minimum of five. The UCS can also be estimated from rock index properties, such as the effective porosity, density, and P-wave velocity. In the case of a porous rock such as travertine, the random distribution of voids inside the test specimen (not detectable in the density-porosity test, but in the compressive strength test) causes large variations on the UCS value, which were found in the range of 62 MPa for this rock. This fact complicates a sufficiently accurate determination of experimental results, also affecting the estimations based on regression analyses. Aiming to solve this problem, statistical analysis, and machine learning models (artificial neural network) was developed to generate a reliable predictive model, through which the best results for a multiple regression model between uniaxial compressive strength (UCS), P-wave velocity and porosity were obtained.

ISRM Online Lectures 2020

En 2020 se han impartido cuatro conferencias online en la ISRM. A continuación se muestran los títulos de las mismas y pinchando en la foto de los autores se puede acceder a cada una de las conferencias.

Diciembre
2020

Empirical Design Methods in
Underground Mining

Prof. Antonio Samaniego



Septiembre
2020

Damage and Time-Dependent
Behavior of Rocks in Underground
Construction

Prof. Frederic Pellet



Junio 2020

Contact Theory and Algorithms for
Discontinuous Computations

Dr. Gen-Hua Shi



Marzo 2020

Rockburst support in shallow-
dipping tabular stopes at great
depth

Prof. François Malan



El Caliz, La Pedriza, Madrid (© J. González-Gallego 2021)



Próximos eventos de interés

XVIII Jornada técnica Anual de la SEMR: Mecánica de rocas y geología estructural	13-05-2021	13-05-2021	España	Madrid
5th International Workshop on Rock Mechanics and Engineering Geology in Volcanic Fields - an ISRM Specialized Conference	09-09-2021	11-09-2021	Japón	Fukuoka
EUROCK 2021 - Mechanics and Rock Engineering from Theory to Practice - the 2021 ISRM International Symposium	21-09-2021	24-09-2021	Italia	ON LINE
ARMS11 - 11th Asian Rock Mechanics Symposium, Challenges and Opportunities in Rock Mechanics - an ISRM Regional Symposium	21-10-2021	25-10-2021	China	Beijing
5th Symposium of the Macedonian Association for Geotechnics - an ISRM Specialized Conference	2022	2022	Macedonia	Ohrid
SBMR2020 - 9th Brazilian Rock Mechanics Symposium - an ISRM Specialized Conference	23-08-2022	26-08-2022	Brasil	Campinas
Eurock 2022 - Rock and Fracture Mechanics in Rock Engineering and Mining - an ISRM Regional Symposium	12-09-2022	15-09-2022	Finlandia	Helsinki
LARMS 2022 - Challenges in rock mechanics: towards a sustainable development of infrastructure - an ISRM International Symposium	16-10-2022	19-10-2022	Paraguay	Asunción
6th Australasian Ground Control in Mining Conference – AusRock 2022 - an ISRM Regional Symposium	29-11-2022	01-12-2022	Australia	Melbourne
15th ISRM International Congress on Rock Mechanics	09-10-2023	09-10-2023	Austria	Salzburgo
XI Simposio Nacional de Ingeniería Geotécnica	24-05-2022	27-05-2022	España	Mieres
7as Jornadas Hispano-Portuguesas de Geotecnia	24-05-2022	27-05-2022	España	Mieres

Muestra de mano pertenecientes a la Colección Hernandez-Pacheco. Laboratorio de Geotecnia, CEDEX. © 2020 CEDEX



Jornadas Técnicas Anuales

Desde el año **2002** la **SEMR** lleva organizando una **Jornada Técnica Anual**, cuya celebración se viene realizando en la segunda semana después de Semana Santa. Tradicionalmente y, gracias a la colaboración del **CEDEX**, esta jornada se realiza en el Salón de Actos de este organismo.

Este acto está dirigido a todos los profesionales vinculados a la Ingeniería del Terreno. Los principales objetivos de las entidades organizadoras son, por una parte, ofrecer a los asistentes la oportunidad de disponer de los conocimientos más avanzados y de las más recientes aportaciones y tendencias en relación con la Mecánica de Rocas y, por otra, servir de foro de discusión que permita el intercambio de opiniones y experiencias entre los diferentes técnicos relacionados con los temas expuestos.

Esta **Jornada Técnica** ha venido teniendo gran acogida entre los profesionales que trabajan en Mecánica de Rocas. La asistencia media suele estar entre 150 y 200 personas, tanto de socios como no socios.

En 2019 la Jornada se celebró el día 8 de mayo con el título “Cavidades en roca”. En 2020 la Jornada se celebrará el día 29 de abril con el título “Geología Estructural y Mecánica de Rocas”.

En la página web de la **SEMR** se puede consultar el programa detallado de todas las jornadas que se han celebrado hasta el momento y que han sido:

- **Excavaciones subterráneas en roca**, 23 de abril de 2002.
- **Taludes en roca**, 23 de abril de 2003.
- **Tratamiento de túneles en roca**, 21 de abril de 2004.
- **Reconocimiento y estudio de medios rocosos**, 20 de abril de 2005.
- **Túneles en rocas blandas**, 26 de abril de 2006.
- **Cimentaciones de presas en roca**, 18 de abril de 2007.
- **Túneles en condiciones difíciles**, 2 de abril de 2008.
- **Cálculo de Túneles**, 22 de abril de 2009.
- **Almacenamiento profundo de CO₂**, 14 de abril de 2010.
- **Últimos Avances en la Mecánica de Rocas**, 4 de mayo de 2011.
- **Ingeniería en Rocas Blandas**, 24 de abril de 2012
- **Cimentación de presas de fábrica en medios rocosos**, 17 de abril de 2013
- **La Mecánica de Rocas en el ámbito de la ingeniería de minas**, 29 de abril de 2014.
- **La Mecánica de Rocas en el Eurocódigo 7 y otras normativas**. 15 de abril de 2015.
- **Últimas técnicas aplicadas en la Caracterización Geomecánica de Macizos rocosos**. 06 de abril de 2016.
- **Casos históricos en Mecánica de Rocas**. 26 de abril de 2018.
- **Cavidades en Roca**, 8 de mayo de 2019.



También se han celebrado varias **Jornadas Extraordinarias**:

- **Tuneladoras en roca**, 16 de marzo de 2006.
- **Experiencias recientes en tuneladoras**, 5 de junio de 2007.
- **Jornada conmemorativa del 50 Aniversario**, 6 de abril de 2017
- **Jornada Extraordinaria en Asturias, Homenaje a P. Ramírez Oyanguren**, Oviedo, 14 de marzo de 2019.

La SEMR en las redes sociales

Tras el éxito de la incorporación, en junio de 2014, de la SEMR a las redes sociales, se renovó en 2015 la web de la SEMR para hacerla más dinámica, accesible y útil para todos los socios.

En la web se informa de todas las cuestiones relativas a la SEMR, tanto desde el punto de vista administrativo y organizativo como desde la difusión de actividades, colaboración con otras entidades, noticias de interés, etc.

Se ha incluido la posibilidad de suscribirse al boletín de noticias para que todo el que lo desee pueda estar puntualmente informado de las últimas novedades en el mundo de la Mecánica de Rocas.

En la web se incluye una sección de publicaciones donde se pueden descargar todos los boletines anuales editados por la SEMR desde el año 2008.

The screenshot shows the homepage of the SEMR website. At the top, there is a banner with the text "Un espacio para la colaboración entre profesionales de la Mecánica de Rocas". Below the banner, there is a section titled "¿QUÉ ES LA SOCIEDAD ESPAÑOLA DE MECÁNICA DE ROCAS?" with a brief description of the organization's purpose and activities. To the right, there is a call-to-action button "HAZTE SOCIO". Further down, there are sections for "Jornadas Técnicas Anuales", "Seminarios y Congresos", "Premios de la SEMR", and "Publicaciones". On the right side, there is a sidebar titled "ÚLTIMAS NOTICIAS" featuring news items like "Curso Online ISRM" and "JORNADA TÉCNICA 2021". At the bottom, there are links for "Aviso legal", "Política de privacidad", and "Política de cookies".

The screenshot shows the Facebook page for the SEMR. It features a profile picture with a globe icon and the text "Sociedad Española de Mecánica de Rocas". The page has 200 followers. A post from "Sociedad Española de Mecánica de Rocas" is visible, showing a photo of a rocky landscape and the text "Feliz Festín / Happy Holidays". The page also includes a "Tweets" section with a post from "Sociedad Española de Mecánica de Rocas" about the 30th anniversary of the Society.

Además, la web cuenta con enlaces directos a nuestras cuentas de LinkedIn, Twitter y Facebook lo que ha sido de gran ayuda para la difusión de noticias relacionadas con la Mecánica de Rocas y actividades de la SEMR.

En la actualidad contamos con más de **2200 seguidores en Facebook, de 2500 en LinkedIn y de 560 en Twitter**.

Animamos a todos nuestros socios a que colaboren en la actividad en las redes sociales de la SEMR publicando comentarios, noticias, eventos de interés, etc.

Enlaces de interés

INTERNACIONALES

- [International Society for Rock Mechanics and Rock Engineering \(ISRM\)](#)
- [Federation of the International Geo-engineering Societies \(FedIGS\)](#)
- [International Association for Engineering Geology and the Environment \(IAEG\)](#)
- [International Commission on Large Dams \(ICOLD\)](#)
- [International Geosynthetics Society \(IGS\)](#)
- [International Society of Soil Mechanics and Geotechnical Engineering \(ISSMGE\)](#)
- [International Tunnelling Association \(ITA\)](#)
- [International Union of Geological Sciences \(IUGS\)](#)
- [Society of Petroleum Engineers \(SPE\)](#)

NACIONALES

- [CEDEX](#)
- [Sociedad Española de Mecánica de Suelos e Ingeniería Geotécnica \(SEMSIG\)](#)
- [Colegio de Ingenieros de Caminos, Canales y Puertos](#)
- [Consejo Superior de Colegios de Ingenieros de Minas](#)
- [Colegio Oficial de Geólogos \(ICOOG\)](#)
- [Asociación Española de Empresas de Ingeniería del Suelo y Subsuelo \(AETESS\)](#)
- [Asociación Española de Túneles y Obras Subterráneas \(AETOS\)](#)
- [Asociación Española de Empresas de Ingeniería \(TECNIBERIA/ASINCE\)](#)
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- Pertener a la ISRM como miembro de la SEMR lo que da derecho al acceso a más información en la página de la ISRM: www.isrm.net:

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 - Participar en Comisiones y grupos de interés de la ISRM.
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