

Artificial Caves from Discovery to Tourist Use

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Italian Show Caves:

An Outline of Regulations Concerning the Design of Tourist Paths

architect Alessio Fabbriatore*

* Alessio Fabbriatore and Partners Technical Office
Chairman of the *Italian Show Caves Association (A.G.T.I.)*
Manager of the *Grotta Gigante (CAI – SAG TS)* – Sgonico/Sgonik (Trieste - IT)

When planning underground tourist paths there are two main aspects that need to be taken into consideration:

- a.* safety, i.e. analysing all possible risks that may arise on the path and providing adequate protection;
- b.* ergonomics, i.e. making paths and steep gradients as easy as possible, bearing in mind that visitors do not always wear adequate clothing (especially shoes).

Among the visitors using tourist paths there may be children, adults not in an ideal shape and disabled people with reduced motor skills, and this must never be forgotten.

Other users are guides, tour leaders and maintenance staff who need to be able to work in total safety, at the same time protecting their own health.

Therefore, all the measures to be taken must be aimed at both the staff's and the visitors' safety, without forgetting to upgrade the site to the maximum: a safe path together with suitable lighting, able to enhance the characteristics of the environment, are indeed very important pluses.

Safety and Environmental Protection Measures

Before and after any maintenance operation it is absolutely necessary to collect all unused materials and take them to the municipal dump, taking great care of polluting, non-inert materials and dangerous substances such as asbestos, acids and other substances described in the rules regulating the disposal of *Dangerous Substances* which may seriously damage health. For the disposal of the latter a special disposal plan must be drawn up by a certified technician. The disposal may be carried out only by registered companies (certified for the disposal of toxic waste), pursuant to Legislative Decree no. 81 of 9 April 2008, Title IX *Dangerous Substances*.

Staff Safety Measures

As regards staff safety (guides and administrative staff), the employer (which may coincide with the legal representative of the company) is under an obligation to appoint a *Person in Charge of Safety, Prevention and Protection (R.S.P.P.)* and an *Occupational Physician* in charge of monitoring the staff's health with regard to health problems relating to the type of activity (for example, exposure to video terminals for administrative staff and radon exposure for guides and tour leaders).

Furthermore it is compulsory to draw up the *Risk Assessment Document (D.V.R.)*, pursuant to the law in force, i.e. Legislative Decree no. 81 of 9 April 2008 (*Implementation of art. 1 of Law no. 123 of 3 August 2007 concerning workplace health protection and safety*), followed by Legislative Decree no. 106 of 3 August 2009 (*Supplementary and corrective measures to Legislative Decree no. 81 of 9 April 2008 concerning workplace health protection and safety*).

In accordance with Legislative Decree no. 241/2000 (*Requirements for workplace radon exposure*) the becquerels per cubic metre (Bq/mc) must be monitored by Certifying Agencies or Bodies accredited by a recognized organization and data must be transmitted to the supervisory bodies (Regional Agency for the Protection of the Environment).

Safety of Tourist Paths

Civil works

Which regulation concerning the safety of tourist paths do underground environments need to refer to? This is not an obvious question at all.

As far as civil works are concerned it is quite easy to answer since these must fulfil well defined requirements for the construction industry and may vary according to regional laws and/or regulations (eg. earthquake-proof building regulations for certain structures).

Of course, any structure, made of wood, concrete or steel, must be designed and assessed by a certified expert and tested by another certified expert according to the laws in force (M.D. 14.01.2008 *Technical building rules*). Great care must be taken with regard to structural elements such as stairs, which are often present *on site*, of which nothing is known from a constructional point of view. In case of doubt, it is advisable to carry out inspections and/or periodical tests on these structures.

In particular, as regards railings, banisters and parapets of stairs and clear spaces, the law provides that vertical posts must be placed at a distance which does not allow a sphere 10cm in diameter to go through them (children must not be able to climb up retaining bars, which must therefore be vertical, not horizontal or made with steel wires) and must be built so that they do not represent an *added danger* or a *design error*. The rule of the 10cm-diameter sphere also applies to the space between each step. Steps must have a rectangular shape (no spiral staircases, no steps on landings, no triangular or trapezoidal steps). On the inner side of the stairs there must not be any overhangs at a distance from the ground which might induce people to rest their feet on them or children to climb over them.

Stairs must always be provided with handrails (on both sides in public areas or if the stairs are wide), which must be uninterrupted along ramps. Parapets and handrails must be 30cm longer at the beginning and at the end of the stairs. Parapets must be at least 1m high (1.10m if the fall risk is over 3m) and must resist a horizontal thrust of at least 2,000 N/m (up to 3,000 N/m) on the handrail, pursuant to M.D. 14.01.2008.

Spiral staircases are not advisable, however if they are used steps must be characterized by a minimum tread depth of 10cm, handrails on both sides and a minimum width of 80-90cm.

As regards gradients, ramps are the ideal solution (when possible) in order to enable disabled people to visit the place.

Laws regulating flooring, sanitation, balconies and terraces (parapets), horizontal paths, stairs and ramps are M.D. no. 236 of 14 June 1989 (*Technical provisions necessary to ensure the accessibility, suitability and visitability of private buildings and subsidized public residential buildings for the overcoming and removal of architectural barriers*) and Presidential Decree no. 503/96 (*Rules for the removal of architectural barriers in buildings, spaces and public services*).

Electrical system

With regard to the standard minimum rules concerning the safety of electrical systems it is necessary to point out the obligation to type-approve earthing systems, as established by Presidential Decree no. 462 of 22.10.2001, Rules simplifying the procedure for the registration of

lightning protection systems and devices, earthing devices for electrical systems and dangerous electrical systems (the employer is under a legal obligation to have the systems checked by a certified body or by ASL/ARPA every 2/5 years; if this obligation is not fulfilled the employer shall be held responsible).

Place of public entertainment

Show caves are not exactly “private buildings” and they may be considered as *place of public entertainment*.

I the undersigned, as the manager of the *Grotta Gigante (Riesengrotte)*, made a request for the type-approval of the earthing system (in compliance with the laws in force) to the A.S.S. of Trieste (the Local Health Authority), in particular to the *Servizio verifiche periodiche (Periodical check service)*. An inspection of the system was carried out by the person in charge, who drew up a report stating that, as regards the use of the *Grotta Gigante* both for guided tours and art shows, its premises are to be considered a “ ... place of public entertainment in compliance with IEC standards no. 64-8/7, paragraph 752.2.”.

General features of the electrical system

The criteria for the design of the electrical system in question need to be defined according to the above-mentioned definition.

The source of the electrical installation must be slightly downstream of the electrical power supply point of the distributing company (ENEL), usually inside a concrete box. Inside this box you must find the main switch equipped with an emergency release coil to which the main riser, which consists of FG7 cables, is connected, leading to the main switchboard, located in a special technical room. This switchboard must be equipped with special protections for the entire electrical system, which is usually divided in two main *zones*, one for the circuits of the reception/administrative area and one for the circuits of the cave area. The entire electrical system must be protected by an uninterruptible power supply, always *on-line*, located next to the main switchboard, in the same room.

Another precaution consists in a diesel generating set, placed in a separated room, for emergency use in the event of unavoidable malfunctioning or black-outs of the entire system. The earthing system is connected to the main earthing terminal within the main switchboard, from which the various protective conductors, characterized by the same section as phase conductors, are distributed to the circuits.

It is then necessary to carry out the following operations:

- a.* exactly define and name the devices relating to the circuit within the main switchboard in order to be able to correctly identify the relative downstream circuits;
- b.* check the mechanical and electrical features of the main supply cable (riser) and measure the isolation voltage, also referring to its junction box. The riser supplies power to the section switchboards;
- c.* install the section switchboards, which consist of watertight boxes, suitable for their laying position and for housing the protection devices of the various downstream circuits and of the terminal boards for the branch connection from the main riser;
- d.* install different types of luminous bodies, in particular ones with differentiated optics according to the object or the scene to be lit up, equipped with lamps of different power;
- e.* install luminous bodies on special supports for emergency and safety lighting of all the cave's pathways that are open to the public using the “always ON” mode, thereby ensuring a minimum lighting level of 5 lux on the steps and 3 lux on the level, 1 meter above the floor.

The functioning of the electrical system must always be assessed in terms of energy saving and lighting performance.

Certified digital audio amplification system

An audio amplification system, in compliance with IEC 60849 standards, is necessary to provide visitors with adequate information in case of failure or accidents. The system needs to be divided in two racks, one inside the cave, provided with all the power amplifiers, and the other one outside the cave, with the control station, its sources and a microphone for general, pre-recorded announcements, connected to a ring optical fibre system, to ensure the functioning of the system in case of an interruption on the system cable.

Radio communication system

As regards communication between the inside of the cave and the fixed listening position, located outside the cave, a radio transmission network is ideal and may be provided with auxiliary relays in order to be able to communicate from anywhere inside the cave with the external operator or vice versa.

The system must be designed both for communicating inside the cave and for emergency use. For standard conversations operators can talk to each other from one portable radio to another and also from the base station.

Portable devices must be provided with a *man down* function which automatically generates an emergency call when the portable radio is in a non-vertical position. In case of emergency, a fixed transmission cycle is activated and whoever is present can voice-communicate with the other devices and with the base station for 15 seconds, after which the radio resets and the base station and the other portable radios are able to communicate with the operator who signalled the emergency.

Lamp flora (photosynthetic organisms that develop near artificial lights)

The development of *Lamp flora* (algae, moss, cyanobacteria and other opportunistic plants) is induced by the presence of lights in caves. These photosynthetic species can seriously damage the underground ecosystems. Unfortunately all light sources, LEDs included, cause Lamp Flora proliferation. In order to get rid of these undesirable species chlorine products are generally used.

Chemical disinfection, with the use of sodium hypochlorite and chlorine dioxide, is the most common method used for this purpose. Their sterilizing action mainly affects the surface of bacterial cells and has little effect on viruses, moulds and spores. However, some microorganisms have become resistant to certain disinfectant substances, thereby limiting their bactericidal effect. Organic material reacts with chlorine, forming compounds called chloramines which can irritate eyes and mucus, have a bad smell and, what is more, have a cancerogenic and teratogenic effect. Chemical disinfectants are also highly corrosive and therefore require special measures to protect the health of those working in contact with these substances.

Sodium hypochlorite, discovered over two hundred years ago and commonly known as bleach or chlorox, is still the most popular disinfectant. It is available in concentrations varying from 1.5% to 5%. Usually it is available in solutions with 3-5% of active chlorine. According to the EEC standards, products containing less than 5% of hypochlorite are not classified, those containing 5-10% must be classified as irritant and concentrations over 10% must be classified as corrosive. Chlorine is a toxic gas and you must avoid inhaling it and wear safety gloves and glasses when handling it.

An excellent alternative to chemical disinfection, enabling you to avoid using substances which may damage the environment, cave fauna and man, is the use of a fraction of sunlight, UVC rays (wavelength 200-280 nm). UVC rays are able to destroy pathogens and prevent their

propagation. They have an effective action on bacteria, viruses, spores, yeasts, moulds, algae and nematode eggs.

On this point, it is worth mentioning, after thorough research and after checking market availability, germicidal lamps, provided with an electronic starter, like *TUV X tra 36W* fluorescent tubes produced by *Philips*, which obtained the *2008 Green certificate* and enable to inhibit the development of *Lamp flora*, thereby ensuring an environmentally-friendly use of caves. These lamps need to be turned on when all the other lights in the cave are turned off. When these lights are on it is necessary to wear special safety glasses as their UV rays may cause conjunctivitis when looking at them with the naked eye.

Fire prevention and public events

As regards fire prevention, it is worth mentioning Presidential Decree no. 151 of 1 August 2011, which is currently in force: *Rules for the simplification of procedures concerning fire prevention, pursuant to art. 49, par. 4-quater, of Legislative Decree no. 78 of 31/05/2010, as amended by Law no. 122 of 30/07/2010* (for example as far as generating sets are concerned).

As regards public event to be held in caves, such as concerts, projections and other events, an authorization request must be sent to the Provincial Fire Brigade Headquarters, which then forward it to the Regional Fire Brigade Headquarters, pursuant to the Ministerial Decree of 19 August 1996, *Approval of the technical rule of fire prevention for the design, construction and use of places of public entertainment*.

architect
Alessio Fabbricatore

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