"Capacity Building and Strengthening Institutional Arrangement"

Workshop: "Environmental Impact Assessment (EIA) (for Assessors)"

Environmental Impact Assessment Models: Noise

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APAT

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Environmental Noise

- Normative aspects;
- Characterization of the area of interest and the acoustic climate ante operam
- Previsional analysis of the acoustic scene post operam;
- Intervention for noise reduction

National regulation on the acoustic pollution

- **DPCM 1 march 1991** "The maximum limits of exposure to the noise in inhabited areas and outdoor"
- **L. 447 26 october 1995**: "Law about acoustic pollution"
- **DPCM 14 november 1997** "Sound source noise limits determination"
- **DM 16 march 1998** "Acoustic pollution measurement methods"
- **D.Leg. 262 4 september 2002** " Directive 2000/14/CE implementation on environmental acoustic emission of machine and devices working outdoor"
- **Regional Laws** in according to the prescription contained in the L. 447/95 and DPCM 14/11/1997
- **DM 29 november 2000** "Criteria for the arrangement of noise reduction plans by Public Transport Authority"
- **DM 1 april 2004** "Guidelines to use advanced systems in environmental impact assessment"
- **D.Leg. 19 august 2005, n°194** "Directive 2002/49/CE implementation related to determination and management of the environmental noise".

DPCM 1 march 1991

- It establishes the acceptability limits of the noise levels, valid on the entire national territory, as protection measures of the environment quality, waiting for the approval of decree that implements the law 447/95.
- It specify **6 classes** of areas in which subdividing the territory from the acoustic point of view, fixing for each one the **maximum limits of acceptability** in the two temporal periods of reference (**day-time 6-22; night-time 22-6**); such limits will only become effective to the completion of the acoustic classification of the territory from part of Common, basing on territorial and urban pointers.

DPCM 1 march 1991

- It fixes the **transient acceptability limits** of immediate application, waiting for acoustic classification, subdivided in **4 zones**:

- entire national territory: limits 70/60 dB(A)
- Zone A: limits 65/55 dB(A) (urban agglomeration that cover a particular historical, artistic and environmental value and sourrounding areas)"
- Zone B: limits 60/50 dB(A) (parts of territory totally or partially built-up areas, different to the zone A)
- Exclusively industrial zone: limits 70/70 dB(A)
- Establish the "differential crieria" for not exclusively industrial areas which evaluate the annoyance respect to the increase generated by the ground noise.

CLASS I – Particulary protected areas 50/40 dB(A)

Belong to this class the areas in which the quiet represent the basic element for their utilization, such as: hospitals, schools, parks, rural residences, etc..

CLASS II - Mainly residential areas 55/45 dB(A)

Belong to this class the urban areas mainly interested to local traffic with low density of population and commercial activities, no artisan activities and factories.

CLASS III – Residential mixed area 60/50 dB(A)

Belong to this class the urban areas mainly interested to town traffic with middle density of population and commercial activities, officies, with low density of artisan activities, no factories; rural areas interested by activities that employ operating machine;

CLASS IV – Very busy areas 65/55 dB(A)

Belong to this class the urban areas mainly interested to intense traffic with high density of population and commercial activities, officies, artisan activities; The areas near the major comunication roads and railway lines, no factories; harbour areas and presence of small factories.

CLASS V – Mainly industrial areas 70/60 dB(A)

Belong to this class the areas mainly interested to factories with low density of population.

CLASS VI – Exclusively industrial areas 70/70 dB(A)

Belong to this class the areas mainly interested to factories and no resident population.

Law n°447, 26 october 1995

It is a **law of principles that postdate to subsequent implementation instruments** the punctual definition of the technical norms and the reference parameters.

- Art.2, are introduced the definitions of fixed and mobile sonorous sources, emission values, immission values, attention values, quality values and immission values refered to environmental noise and differential noise.

- Art.4-6 Municipalities must proceed to edit the **territorial acoustic classification** in the respect of DPCM 1/3/91.

Law n°447, 26 october 1995

➢Art.7, Municipalities must adopt the **plan for the acoustic improvement of the territory** when the sounds levels measured exceed the attention values or between contact areas with noise levels exceeded 5 dB(A). This plans must contain:

- the location of the typology and entity of the present noises, mobile sources included, in the detected zones to reclaim in according to the classification of the communal territory (art.6 paragraph 1 letter a).
- The location of the subjects which the operation competes (RFI, ANAS, etc);
- The location of the priority, modality and reclamation times;
- Estime of the financial burden and necessary means;
- Urgent precautionary measures for environment and public health preservation;

DPCM 14 november 1997

This DPCM, implementing the art. 3, paragraph 1, letter a) of the law n° 447/95, fixes the emission, immision, attention noise limits and the quality values as in the art.2, paragraph 1, letters e), f), g) ed h); paragraph 2; paragraph 3, letters a) e b), by the same law.

It contains new emission and immission limit values (in subtitution of the same limits estabilished from the DPCM 1° march 1991) holding the acoustic classification of the territory as DPCM 1/3/1991.

The implementation of the new limits is conditioned by the editing of the acoustical classification of the territory from the Municipalities, as in the art. 6, paragraph 1, letter a) of L.447/95.

DPCM 14 november 1997

Destinazione d'uso territoriale	Valori limite di emissione in dB(A)		Valori limiti assoluti di immissione in dB(A)	
	Diurno	Notturno	Diurno	Notturno
I – Particularly protected areas	45	35	50	40
II– Mainly residential areas	50	40	55	45
III – Residential mixed area	55	45	60	50
IV – very busy areas	60	50	65	55
V- Aree prevalentemente industriali	65	55	70	60
VI- Exclusivity industrial areas	65	65	70	70

DM del 16 march 1998

- **It specifies the methodologies for the railway and road noise measurement**. About the railway noise, it indicates an altitude from land of 4 meters and a distance between the building faces of 1 meter. It comes moreover specified the procedure of calculation of the exposition level, indicating a minimal measure time of 24 h. About the road noise, basing on the hypothesis that the traffic is a random or pseudo-random phenomenon, it comes indicated a time of minimal measure equal to one week, with a measure scanning equal to 1 h on all the 24h.
- It indicates the typology of a phonometer for equivalent level measures (class 1 in compliance with norms EN 6065/1994 and EN 60804/1994), the modalities and the times of calibration.

DM del 16 march 1998

It specifies the definitions related to the times and range of measure, to the levels of noise; it indicates the corrective to apply in presence of noise with impulsive components, pitch or in low fequency (such factors are not applicable to transport infrastructures).

- It indicates the procedures to execute measurements and it reconfirms that already present in the norms antecedent with respect to localization of the microphone for the measures in outside and inside of inhabited environments and about the meteorological conditions compatible to the same measure.
- It comes specified that the operator must be to a distance greater than 3 m from the same microphone during the measure.
- It describes the methodology for results presentation, indicating the data to report in the final document, as the name of the observatories that have attended to the measurement and the competent technician.

D.Leg. 262 4 september 2002

Related to the **construction phase** is applicable the D.L 262/02; while, related to the D.P.C.M. 1-3-91, are true the dispositions contained into the art. 1 paragraph 4, that is: “The temporary activities, which construction site, the manifestations in a public place or opened to the public, in case they involve the employment of machinery and noisy systems, must be authorized also in exception to the limits of present decree (D.P.C.M. 1/3/91) from the Mayor which establishes opportune prescription in order to limit the acoustic pollution, felt competent ASL (Local Health Service)”.

The D.L. 262/02 discipline the emission acoustic values, the evaluation procedures of the conformity, the mark, the technical documentation and the data acquisition about **sonorous emission of outdoor machinery and equipment**, for the human health and the environment protection.

It is applied to machinery and equipments working in outdoor detected and defined to article 2 and in the enclose 1 that, since the date which the present decree has become effective (January 2003), are putted in commerce.

The D.L. 262/02 establish the following limits of sonorous power dB (A) of the produced noise, outdoor, from the machinery of construction site, depending from the installed net power (kW), like reassumed in the following table for some relevant machinery:

Typology of Machinery	Installing net power (P) in kW Electric Power (Pel) in kW Equipment mass (m) in Kg	Accepted sonorous power level LwA in dB(A)	
		Phase I since 3 gennuary 2003	Phase II since 3 gennuary 2006
Excavators, freight elevator for material from construction site, winches	P<=15	96	93
Hammerings held demolishers by hand	15 <m <30	94 +11 lg m	92+11 lg m
Group electricity-generating and electricity-generating groups of welding	Pel >10	97 +lg Pel	95 +lg Pel

DM 29 november 2000

- ✓ It establishes the criteria for the predisposition, by the societies and the agencies managers of the transport public services or relative infrastructures, there-comprised the highways, of the plans for contains and decreases the noise produced by the above-mentioned infrastructures.
- ✓ Fixes the modality and the presentation terms of the plans to the interested Municipalities, Regions and to the Ministry of the Environment:
  - ✓ The location of the intervention;
  - ✓ Relative realization modality (are mentioned also the project criteria)
  - ✓ Execute timming and costs
  - ✓ Priority degree of each-one;
- ➢ It indicates the target of the reclamation in reference to obtain the immission limit values within the acoustic pertinence area of the single infrastructure, contained in the rispective implementing decrees (for example: DPR459/98 for railway infrastructures).

DM del 1 aprile 2004

- It locates the guidelines for the use of innovative systems to decrease and mitigation of the environmental pollution to which the proposer must be adhered writing the plans.

Interested area and acoustical climate ante-opera characterization

- **Description of the area interested by the project:**
  - Typology, morfology, territorial meteo data (photo, chart);
  - Territorial destination use (ref. To Municipalities General Regulation Plan GRP);
  - Census of the receptors (every building used as inhabited environment, comprised the relative external pertinence areas; bound naturalistic areas, parks publics and external areas destined to recreational activities and to the development of the social life of the collectivity; building territorial areas almost characterized in the GRP) as defined in DPR 459/98;
  - Location of the receptors " particullary sensitive" as schools, hospitals, nursing home, rest home.
- **Acoustic state definition of the interested area:**
  - reference to Municpiality acoustical classification;
  - Location of the sonorous sources actually present in the area;
  - Phonometrical mesurements campaign in the sensible receptors (as indicated in the DM 16/3/98).

Previsional analysis of the post-operam acoustical scenario

- **location and definition of sonorous sources** scheduled in the *realization and operation phases* of the plant or infrastructure;
  - Location, typology, number, times functioning (continuous, discontinuous, day, nightly).
- **Acoustical characterization of the sources (emission produced)**
  - Literature data (sonorous power), direct measures on similar machinery in the same contests.
- **Acoustic levels evaluation induced** on the territory from the project in the realization and operation phases, **in day and naightly scenarios**.
  - Acoustic simulation models;
  - Acoustic maps of the interested area (isophonic curve)

Acoustic simulation model

Allow, in according with the norm *ISO 2631*:

- **Determining noise propagation** of multiple and various typology sources, such as: punctual, linear, aerial, industrial, road, railway and airport;
- **Entering three-dimensional morphology of the land** (level curves), the elements present on the land (buildings, walls, vegetation) and the data related to the sources (sonorous power, directivity and temporal emission variation);
- **Calculating the equivalent continuous level** (basing on the temporal reference periods such as: hours, day, nightly) in every point indicated and showing graphically the results with isophonics overlapping to the topography of the area, both two and three-dimension, or in analytical mode on the single receptors);
- **Taking into account land and air absorption,** obstacle reflection and the shielding objects attenuation, meteorological effect (direction and speed of the wind)

Acoustic simulation model

- **Explaining acoustical impact mitigation** (barrier) basing on law limits: acoustical classification of the territory, DPR 459/98 (railway), DPR 142/04 (road), DM 31/10/97 – DM 20/05/99 – DM 03/12/99 (airport).
- Actually the most advanced and used models for the noise mapping are Mithra and SoundPlan, that permit to execute noise propagation simulation basing on all the above-mentioned parameters.

Intervention for noise reduction

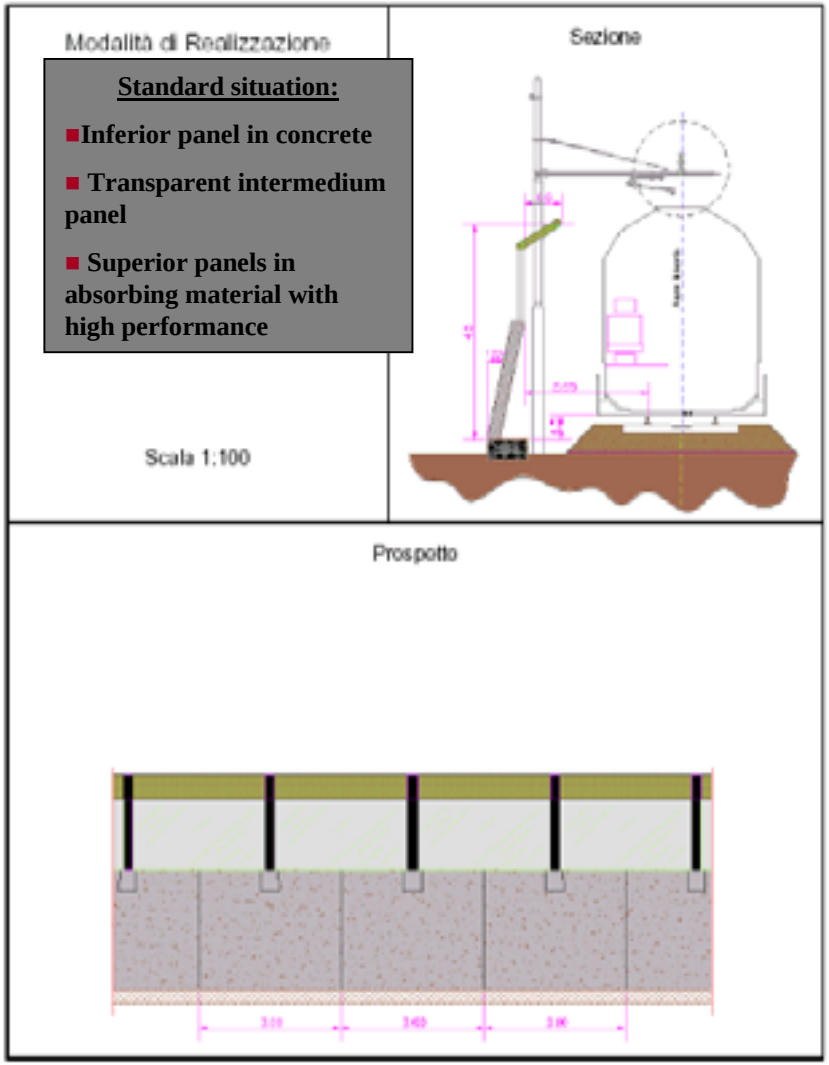
- **Realizing phase (construction site):**
  - Machinery and equipment selection complying to the national and community machinery directive;
  - Screens for noise isolation;
  - Regular and opportune maintenance of the means and equipments;
  - Correct working-plan and programming of the construction-site;
  - Temporary barrier placement in the border line of the construction-site and along the ways of the working means;
- **Operating phase (road, railways and industrial plant infrastructures):**
  - Phono-absorbing asphalt, barriers, silent joint, low emission machinery, phono-isolating windows-lock on receptors.

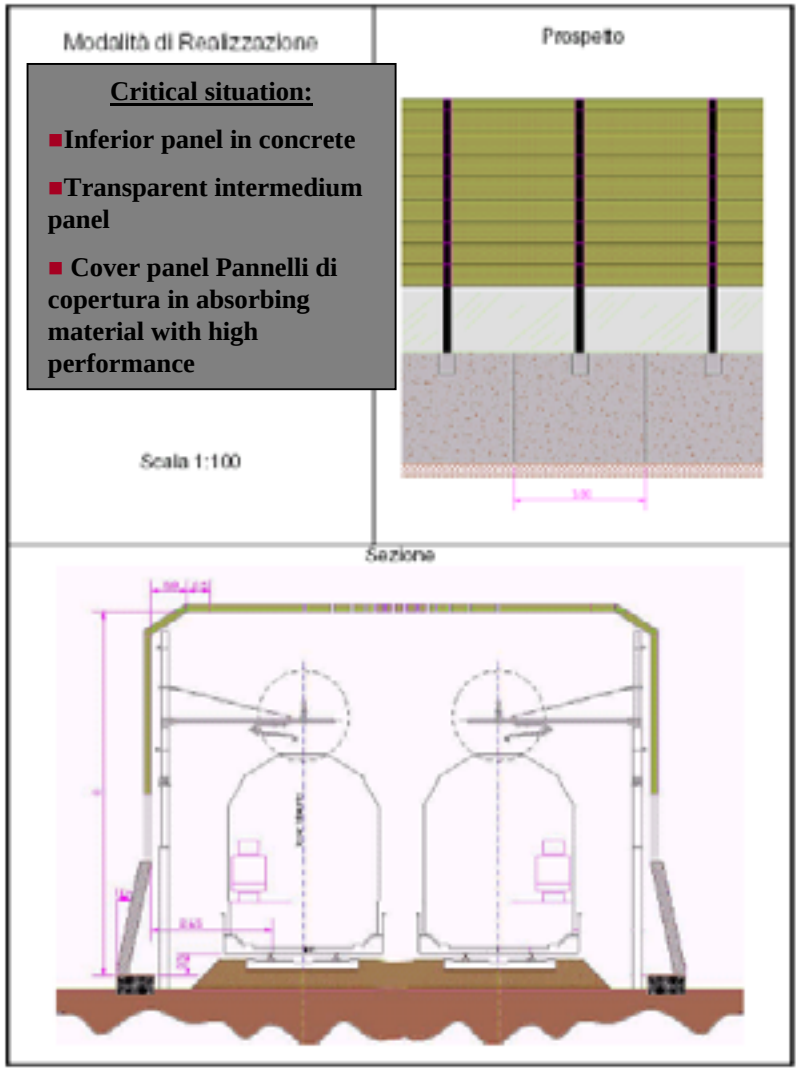
Characterization and costs index for noise reduction intervention (from DM 29/11/00)

Type of intervention	Field of employment	Effectiveness	Unit cost (indicative)
Traditional anti noise paving	In non particularly critic situations or as for integration of other interventions	3 dB for all receptors, independently of the height relative to the infrastructure	8.00 €/m² of road surface treated
Artificial anti noise barriers (metallic, wooden, concrete, expanded clay, transparent, bio-walls)	Typically, in presence of medium height receptors, near infrastructures	14 dB for receptors in the A zone of the shadow 7 dB for receptor in the B zone of the shadow 0 db for receptors out of shadow zone	210.00 €/m²
Artificial anti noise barriers, integrated with an antidiffractive element on top	Typically, in presence of medium height receptors, located near infrastructures; with a high density of receptors in the shadow zone	15 dB for receptor in the A zone of the shadow 7.5 dB for receptors in the B zone of the shadow 0 db for receptors located out of shadow zone	300.00 €/m² for interventions on railways in operation
Anti noise barriers made by an alveolar wall, greened with concrete or wood	Typically, in presence of medium height receptors, located near infrastructures	19 dB for receptors in the A zone of the shadow 10 dB for receptors in the B zone of the shadow 0 db for receptors located out of shadow zone	255.00 €/m² for new railways, roads, highways or existing routes with possibility of traffic deviation
Vegetative anti noise barrier	Typically in non particularly critical situations, with wide, not built strip of territory in between the receptors and the road seat	1 dB for every 3 metres thickness of the planted strip	80.00 €/m² of planted soil, with exception of cost of the ground

Type of intervention	Field of employment	Effectiveness	Unit cost (indicative)
Anti noise embankment	It requests a not built territory strip between receptors and infrastructures equal to 2.1 times the height of the embankment. This provision can be integrated with vegetative barriers	13 dB for receptors in the A zone of the shadow 6 dB for receptors in the B zone of the shadow 0 db for receptors located out of shadow zone	160.00 €/m for heights <= 3m from the ground level of the infrastructure, without planting, excluding the cost of the site 260.00 €/m for heights >3m from the ground level of the infrastructure, without planting, excluding the cost of the site
Total covering (roofing)	Highly populated areas, with buildings higher than the infrastructure and a high level of noise	> 25 dB	450.00 €/m² ofcovered road seat
Silent joints	For receptors located nearby bridges or viaducts; the provision integrates others, in order to reduce impulsive sounds	3 dB of Lmax	630.00 €/m for joint excursion of ± 15 mm 10,500.00 €/m for joint excursion of ± 50 mm
Self ventilating anti noise windows	For situations particularly severe, not completely recoverable with passive interventions on the structure. They are suitable also with other types of interventions	34 dB	• 1560.00 €/m for windows with natural ventilation • 1850.00 €/m for windows with forced ventilation
Sound deadening material for building facade	In densely urbanized areas, with the aim of improving the acoustic climate of the zone	3 dB	55.00 €/m²
Sound deadening at tunnel entrance	Areas with buildings nearby tunnels; the intervention foresees the internal covering of the gallery	2 dB, up to 30 m from the entrance	26,000.00 € per entrance

Examples of artificial acoustic barriers about railway infrastructure





RFI: Piani di Risanamento Acustico - 2002

Vibrations

- Normative aspects;
- Characterization of the area of interest and the vibrational state ante operam
- Previsional analysis of vibrational assessment post operam;
- Mitigation for vibrations reduction

National regulation on the vibrational pollution

Actually does not exist a national norm that establishes quantitative limits for vibrational exposure. Exist national and international technical norms, that constitute a useful reference for the disturbance evaluation in buildings interested from vibration phenomena.

- ✓ISO 2631-2: “Evaluation of human exposure to whole-body vibration” – vibrations on buildings
- ✓UNI 9614: “Vibration measurement in buildings and annoyance evaluation”
- ✓UNI 9916: “Criteria for the measurements of vibrations and the assessment of their effects on buildings”.

ISO 2631-2: Evaluation of human exposure to whole-body vibration – vibrations on buildings

- ✓ It is applied to vibrations transmitted from solid surface along the axes x, y and z in a range of frequency comprised between 1 and 80 Hz for persons up, sitting or coricate.
- ✓ It indicates the multiplication factors to apply to the basically curves to the aim to define the curves limit of the acceptable maximum acceleration, to varying the reference period (daytime and night time), of the type of transitory vibration (continuous or intermittent, transient vibrations) and of the inhabit type (hospitals, laboratories of precision, residences, offices, industries).

UNI 9614: Vibration measurement in buildings and annoyance evaluation

- ✓ Substantially in according to the ISO 2631- 2, but more restrictive.
- ✓ It defines the limit values of the accelerations for the 3 axes over of which the vibrations can objective be disturbing.

Use destiation	Axe Z (m/s^2)	L(dB)	Axes X e Y (m/s^2)	L(dB)
Critical area	$5.0*10^{-3}$	74	$3.6*10^{-3}$	71
Inhabit (night/day)	$7.0*10^{-3}$ /$10*10^{-3}$	77/80	$5.0*10^{-3}$/$7.2*10^{-3}$	74/77
Officies	$20*10^{-3}$	86	$14.4*10^{-3}$	83
Industries	$40*10^{-3}$	92	$28.4*10^{-3}$	89

UNI 9916: Criteria for the measurements of vibrations and the assessment of their effects on buildings

- It supplies a guide for the choice of the measurement methods, data processing and vibrational impact assessment of vibrational phenomena on the buildings, with reference to their structural answer and to architectonic integrity, considering a frequency range of the phenomenon between 0.1 and 150 Hz.
- It comprises residential buildings and building for professional activities, public buildings, old and ancient buildings with architectonical, archaeological and historical value, light industrial structures.
- It suggest the factors from which depend the structure reaction to the vibration effects:
  - Structure class: two classes (old buildings or builted with traditional criteria; modern buildings and structures)
  - Foundation; 3 classes (A – poles in concrete armed (CA); B- poles not tied in CA; C – light wall, by stone, without foundation);
  - Nature of the land: 6 classes from not fissure rocks and much solid to report material;

Interested area and vibrational state ante-opera characterization

- Nature of the land: geological chart, geological report, polls.
- Receptor typology: state, building criteria and foundation.
- Presence of significant vibrational source: industrial plants, roads, railways, pit and construction-site.
- Evaluation of existing vibrations by means acceleration and reference speed measurements for the three axes.

Vibrational impact analysis on realizing and operating phases

- Typology of the scheduled works.
- Machinery utilized in the operations;
- Points of employment of the fixed equipments and route of weighing means;
- Lenght and cicles of most impact working processes;
- Estime of the vibrazionali effects on the base of the effects and the evaluation carried out in similar situations and in presence of machinery and analogous workings.

Intervention for vibrational reduction and mitigation

- bearings, plates and shock absorber place at the base of equipment and fixed machinery.
- Visco-elastic burrow diaphragm, between source/activity and receptor able to absorb and/or reduce the vibrational effects transmitted on land.
- Machinery selection criteria (in positive situation of vibrational transmission and near sensitive receptors (within 50 m)): rotation machine for poles making (not percussion), rubberizing means (no caterpillar) for movements of the ground, no explosive.

Intervention for vibrational reduction on the connections

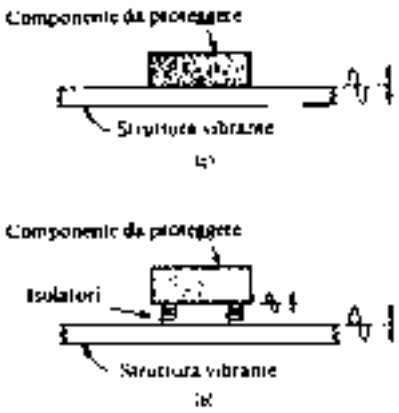


Fig. 20.1 - Rappresentazione schematica di un componente connesso a una struttura che vibra:
(a) senza isolatori
(b) con isolatori

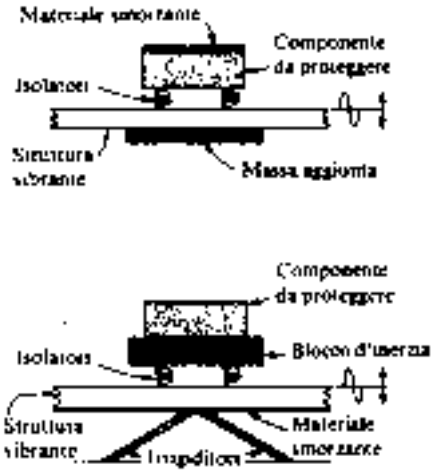


Fig. 20.2 - Rappresentazione schematica dei mezzi per ridurre le vibrazioni di un componente connesso a una struttura vibrante (si paragoni alla fig. 20.1).

Metodi per ridurre le vibrazioni

Per ridurre la vibrazione di un elemento agganciato a una struttura che vibra, si può impiegare uno o più dei seguenti mezzi:

1. *Riduzione della vibrazione della struttura nel punto di connessione.* In funzione della struttura e delle frequenze relative, si può ottenere tale riduzione aggiungendo elementi elastici, masse o smorzatori, come mostrato in fig. 20.2. Ad esempio, la riduzione delle vibrazioni di una struttura a lastra (a frequenze superiori a circa 30 Hz) può essere ottenuta in modo molto semplice aggiungendo delle masse (in genere almeno doppie della massa della struttura locale in vibrazione).
2. *Inserimento di connettori soffici (isolatori di vibrazione)*, come schematizzato nelle figure 20.1 e 20.2. Tali connettori dovrebbero essere il più possibile soffici, coerentemente con i limiti pratici dovuti alla flessione prodotta da carichi statici e da urti. Gli isolatori di vibrazione devono essere abbastanza soffici in modo che la frequenza naturale f_n dell'elemento da proteggere, agganciato agli isolatori, sia inferiore di almeno un fattore 2 rispetto alla frequenza d'eccitazione più bassa (gli isolatori di vibrazione sono trattati in modo più dettagliato in seguito, nel presente capitolo).
3. *Aumento della rigidezza dell'elemento da proteggere*, o almeno della base su cui è montato, in modo che esso si deformi meno a causa delle vibrazioni. L'aumento della rigidezza può richiedere un nuovo progetto della struttura dell'elemento, l'aggiunta di rinforzi e/o l'aumento dello smorzamento (fig. 20.2).
4. *Aumento della massa dell'elemento da proteggere* ottenuto montando l'elemento su una piattaforma rigida o entro un'incastellatura rigida (fig. 20.2). La massa aggiunta, definita «blocco d'inerzia», produce un abbassamento della frequenza naturale f_n dell'elemento che deve essere protetto, come esso fosse montato su degli isolanti di vibrazione. L'aumento della massa di un dato fattore ha il medesimo effetto della riduzione della rigidezza degli isolanti dello stesso fattore comunque, di solito, senza introdurre i problemi che derivano dalle grandi frecce dovute alle forze di transitorio o d'urto.
5. *Uso di due stadi di isolatori di vibrazione* per mezzo del sistema a doppio isolamento con massa interposta, come illustrato in fig. 20.3. L'isolamento a due stadi può essere di estrema efficacia per ridurre le vibrazioni alle alte frequenze, ma può aumentare le vibrazioni alle basse frequenze(*).

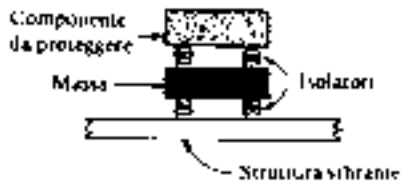


Fig. 20.3 - Rappresentazione di un isolamento a doppio stadio. I due sistemi d'isolamento dalle vibrazioni hanno la medesima rigidezza.

Fonte: MANUALE DEL CONTROLLO DEL RUMORE - Harris