

Activities about NORM and building materials in Italy

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Italian approach to the transposition of the Council Directive 2013/59/Euratom about NORM and building materials.

- In 2014 a working group (WG_{BSS-IT}) was created in order to elaborate the new text of the Italian Basic Safety Standards.
- Due to complexity of this Directive and the width of application field, the WG_{BSS-IT} was formed by many members coming from Ministries (Health, Economic Development-coordinator, Research and University, Labour and Social Policy, Defence, Justice, Interior), Governmental Bodies (Inst. for Environmental Protection and Research, National Institute of health, National Workers Compensation Authority, National Fire Corps, Civil Protection Department) and some Regional Bodies. People officially involved in the WG_{BSS-IT} are about 60.
- WG_{BSS-IT} has been divided into **one Editorial Group (EG)** composed by representatives, generally one, of each Ministry and Governmental Bodies, and eight Thematic Groups (TG):

Italian approach to the transposition.....(cont.)

eight Thematic Groups (TG):

TG 1 - Scope, Definitions, System of radiation protection;

TG 2 - Regulatory control of practices;

TG 3 - Protection of workers;

TG 4 - Protection of members of the public;

TG 5 - Emergency situations;

TG 6 divided into

TG6a - Radon

TG6b - NORM and existing exposure situations;

TG 7 - Medical exposures;

TG 8 - Penal provisions.

TG 6b is dealing with the transposition in the Italian BSS of the EU BSS NORM and building material approach and relevant articles.

Italian approach to the transposition - NORM

- The Italian law in force follows the Directive 96/29/Euratom approach and sets a positive list of industrial activities that can be of radiological concern.
- NORM industries individuated and listed are not a practice, but they have to evaluate doses to workers and population caused by their production processes.
- If an NORM industry determines, even after remedial actions (three years), annual effective doses for workers and/or population exceeding the relevant action levels (1mSv and 0.3 mSv), it will be considered as a practice.
- The Directive 2013/59, on the contrary, considers NORM industries listed in the Annex VI as practices *a priori* and in Annex VII sets a “**general exemption and clearance criteria**” in term of dose of **1 mSv per year**. Below this value, the NORM industry is out of the Directive application field.
- Apparently two opposite approaches, but transposition of the Directive 2013/59 in the Italian law seems not determining substantial problems because presently, if an industry is in the positive list of sectors of concern must anyway evaluates doses, and doesn't matter if it is or not a practice.

Italian approach to the transposition – NORM (cont.)

The novelty to be introduced in the Italian law is the **exemption/clearance level** for natural activity concentrations of solid materials involved in the industrial process under examination (1Bq/g for U and Th and 10 Bq/g for K Annex VII of BSS 2013/59).

These EU common levels should guarantee free movement of goods and services in the EU internal market and simplify procedures.

If measurements of materials in all phases of production process (raw materials, products, residues) detects activity concentrations lower than the exemption/clearance values, industry is not in the law application field.

In all the other cases, the undertaking must evaluate doses to workers and population and compare them with the “general exemption and clearance criteria” in terms of dose.

Italian approach to the transposition – Building materials

Like many countries in EU, Italy is facing this normative issue for the first time. Many critical aspects:

- Individuating positive list of materials (different in different countries).
- Use of the index **I** (annex VIII) to screen materials of concern (**reference level = 1 mSv per year**);
 - application of I to composed materials (single component and its fraction of use should be considered: e.g. concrete);
 - application of I to lighter/thinner materials (bricks).
- Rn from building materials (National Rn Plan).
- Agreement with the the Regulation 305/2011 about building products and individuating authorities in charge for controls.
- Accounting for the CEN standard still in finalization.

The Italian WG is preparing a draft aimed to consider all these aspects.

NORM and Building Materials

Some NORMs are traditionally used in building materials (BM), typically as cementitious component (fly ashes, metall. slags, silica fumes, etc.).

This is the most important NORM exposure pathway for population (RP 112, NRPB R286).

Due to the huge amounts of NORM residues produced, experimental and theoretical studies have been conducted to assess the feasibility and sustainability of a larger reuse as components in building materials, and the EU is supporting a COST Action on this topic (NORM4BUILDING: original nucleus from EAN-NORM).

However, addition of NORM should not, first of all, pose a threat to the material user during the “life cycle” of these materials and deteriorate the quality of building material itself.

NORM and Building Materials- Database information

Research in this field was considered useful:

- a) to provide an overview of the **radiological content** in NORM residues used in building material production;
- b) to evaluate the **radiological impact** of building materials containing NORM residues;
- c) to elaborate a **new screening tool** accounting for other important factors affecting the indoor exposure.

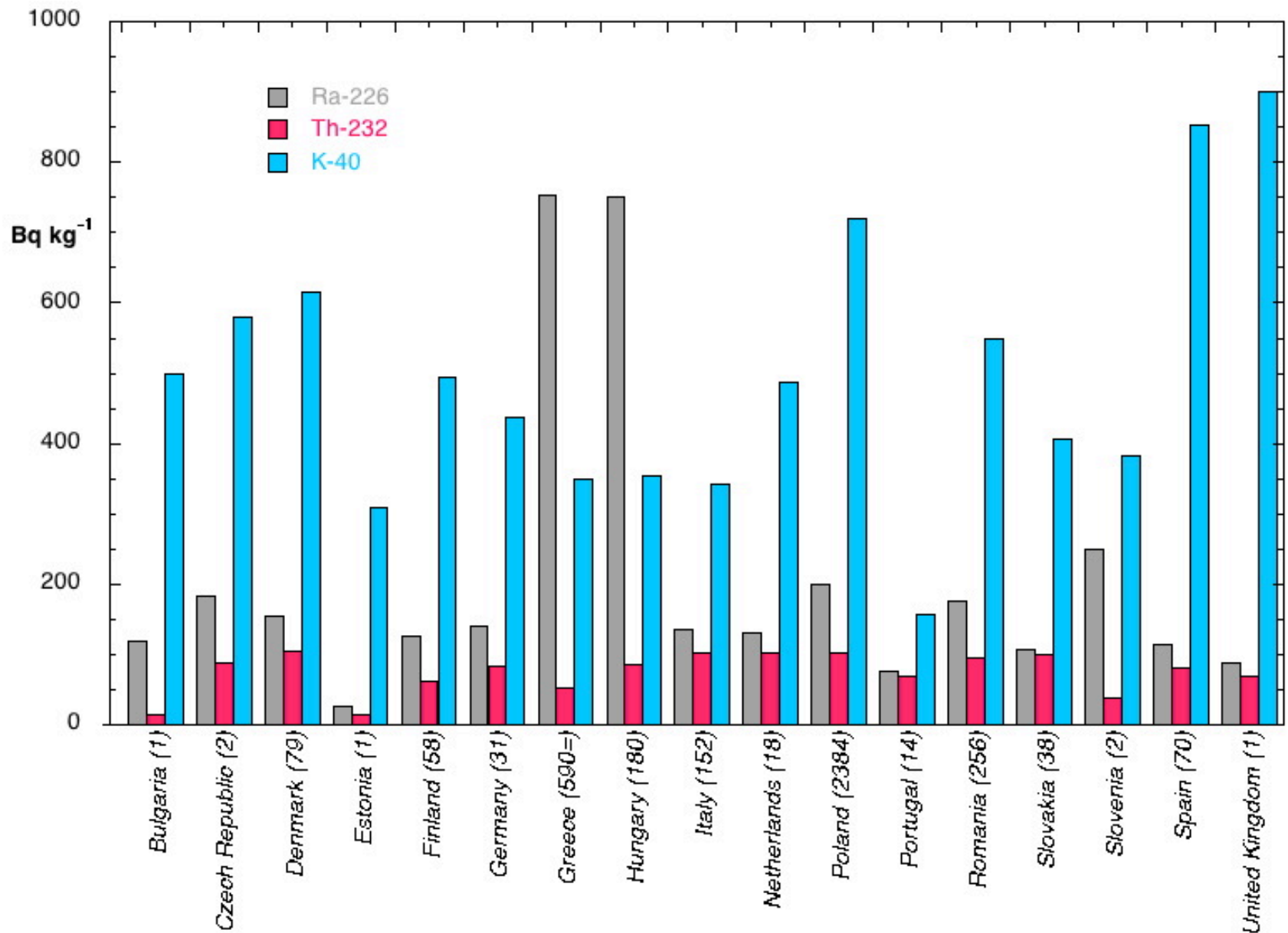
Database contains data of byproducts from 20 out of the 28 MS. This sub-database is part of the database of building materials in EU.

(22000 samples: 1860 bricks, 2546 cements, 3347 concretes, 3360 aggregates, 1300 tiles, 310 superficial stones, etc..).

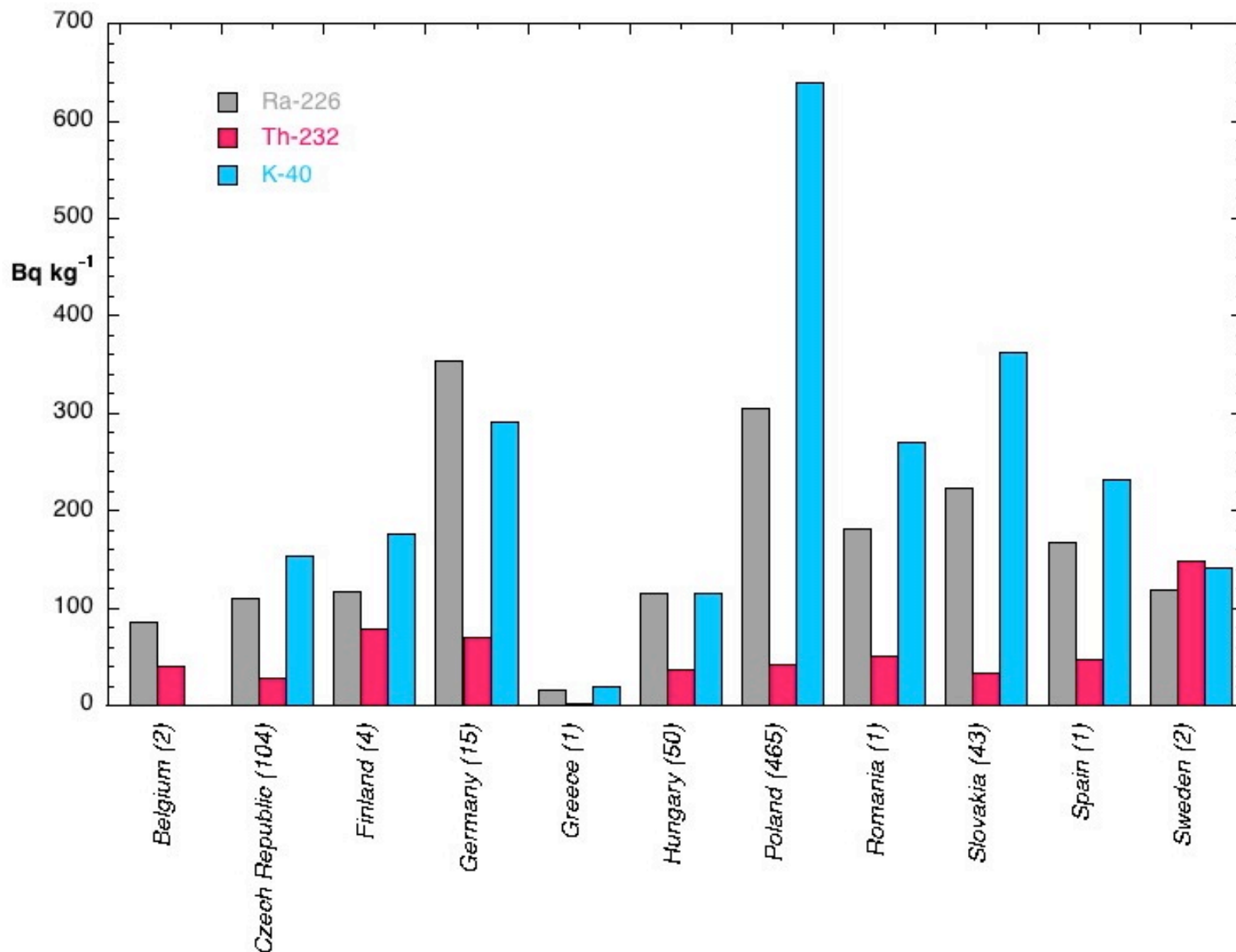
Different byproducts added in standard building materials, or used as they are, were considered:

- ✓ fly ash (about 5500)
- ✓ furnace slag (about 690)
- ✓ phosphogypsum (about 380)
- ✓ others (about 270) not analysed

Natural radionuclides concentrations in fly ashes used in building materials (17 EU MS – 5512 samples)



Natural radionuclides concentrations in furnace slags used in building materials (11 MS – 689 samples)



Fly ash and slag in building products

These byproducts are already used - for many years - as cementitious material:

- ✓ Fly ash - pozzolanic properties
- ✓ Blast furnace slag - reduction of permeability, increased density

Research activities have been recently devoted to their use as aggregates (fine and/or coarse) in new materials maintaining same characteristics and properties of standard concrete (Australia, India, Japan, US...).

With the typical concrete composition (20% cement, 35% fine aggregate, 45% coarse aggregate) realistic hypotheses were applied to calculate I_{BSS} .

	Current byproduct use		Studied and possible byproduct use in the future	
	Cement	Aggregates	Cement	Aggregates
Fly ash	25%	-	25%	35% (fine)
Furnace slag	50%	-	50%	50% (coarse)

Cement: ²²⁶Ra, ²³²Th and ⁴⁰K activity concentration (2036 samples)

Country	N. of samples	²²⁶ Ra (Bq kg ⁻¹)	²³² Th (Bq kg ⁻¹)	⁴⁰ K (Bq kg ⁻¹)
Austria	18	27	14	210
Belgium	26	52	46	255
Bulgaria	1	29	19	160
Cyprus	20	23	8	136
Czech Republic	496	46	19	237
Denmark	6	20	12	90
Finland	11	40	20	251
France	1	35	21	24
Germany	23	86	73	170
Greece	183	85	19	257
Hungary	400	30	22	218
Ireland	3	60	11	131
Italy	200	41	63	357
The Netherlands	17	62	64	271
Poland	344	73	66	353
Portugal	8	31	19	256
Romania	55	44	27	233
Slovakia	6	35	18	223
Spain	182	70	49	273
Sweden	30	53	54	224
United Kingdom	6	22	18	160
Overall average		46	32	214

Percentage of concrete samples with I_{RP112} exceeding the screening level =1

	Use in cement $I_{RP112} > 1$	Use in cement and aggregates $I_{RP112} > 1$
Fly ash concrete (968 samples in 14 MS)	0%	28%
Furnace slag concrete (145 samples in 7 MS)	0%	32%

Modelling

This Directive introduces the index I_{RP112} , relating to gamma dose, from RP 112 to screen building materials of radiological concern

$$I_{RP112} = C_{Ra-226}/300 + C_{Th-232}/200 + C_{K-40}/3000$$

"The activity concentration index value of 1 can be used as a **conservative screening tool** for identifying materials that may cause the reference level... to be exceeded..."

If the screening value is exceeded, dose must be calculated with more detailed procedures

"**The calculation of dose needs to take into account other factors such as density, thickness of the material as well as factors relating to the type of building and the intended use of the material** (bulk or superficial)." (Annex VIII, BSS Draft 13675/13).

Modelling

I_{RP112} was developed to account for average concrete values of d and ρ , the main structural characteristics of building material affecting the gamma irradiation.

This screening procedure could unfit in case of significantly different d and/or ρ of the building materials under examination.

A new screening tool, still conservative but more realistic, accounting for these important factors affecting the indoor gamma exposure was elaborated.

This index can be helpful for screening both existing materials containing NORM and, in particular, the new ones (e.g. geopolymers).

Another index function of d and ρ has been developed by CEN/TC 351/WG3/TG32 and presented in a technical report final draft circulating for consultation.

A proposal for a general index to accounting for material characteristics ρ and d

The index I_{RP112} from RP 112

$$I_{RP112} = C_{Ra-226}/300 + C_{Th-232}/200 + C_{K-40}/3000$$

can be considered a **particular result** in case of concrete of a more general index $I(\rho d)$ function of ρ and d .

$I(\rho d)$ has the same structure of I_{RP112} but A_{Ra} , A_{Th} e A_K depend on $\rho \cdot d$

$$I(\rho d) = \frac{C_{Ra-226}}{A(\rho d)_{Ra-226}} + \frac{C_{Th-232}}{A(\rho d)_{Th-232}} + \frac{C_{K-40}}{A(\rho d)_{K-40}}$$

A proposal for a general index to accounting for material characteristics ρ and d (cont.)

$$I(\rho d) = \frac{C_{\text{Ra-226}}}{A(\rho d)_{\text{Ra-226}}} + \frac{C_{\text{Th-232}}}{A(\rho d)_{\text{Th-232}}} + \frac{C_{\text{K-40}}}{A(\rho d)_{\text{K-40}}}$$

The general expression of $A_x(\rho d)$ is

$$A(\rho d)_x = m_1 [1 + m_2 (\rho d)^{-1} + m_3 (\rho d)^{-2}]$$

Typical ρd values are:

concrete = 450 - 470 kg m⁻²

bricks = 210 - 330 kg m⁻²

Some mathematical remarks

1) The structure of $A(\rho d)_x$ determines that

$$I(\rho d) \Rightarrow 0 \quad \text{when } \rho d \Rightarrow 0$$

2) The m_1 's are the values of the $A(\rho d)_x$ when $\rho*d$ tends to infinity



m_1 's are the lower limits of the activity concentrations determining
1 mSv per year from any kind of building material.

$$m_{1\text{Ra-226}} = 182 \text{ Bq kg}^{-1}$$

$$m_{1\text{Th-232}} = 140 \text{ Bq kg}^{-1}$$

$$m_{1\text{K-40}} = 1969 \text{ Bq kg}^{-1}$$

Application of the new index $I(\rho d)$ to the BM database

In order to evaluate $I(\rho d)$ utility, concrete and brick data were used

✓ concrete (~ 2700 samples)

✓ bricks (~ 1600 samples)

Indices (annual dose 1 mSv)	Building material	
	Bricks (1607 samples)	Concrete (2714 samples)
$I(\rho d)$	0%	5%
I_{RP112}	5%	5%

As expected, $I(\rho d)$ application to concrete gives same results of I_{RP112} (elaborated for ρ and d of concrete).

Utility of $I(\rho d)$ emerges from its application to other materials, e.g. bricks with $\rho = 1500 \text{ kg m}^{-3}$, $d = 0.15 \text{ m}$

All 1607 samples of bricks have $I(\rho d) < 1$.

What about Rn?

Very different reference levels for

✓ γ indoors: 1 mSv γ^{-1} **from BM**

✓ **Rn**: 300 Bq $\text{m}^{-3} \sim 12 \text{ mSv } \gamma^{-1}$ (ICRP statement 2009) **from soil and BM**

Difficulties in elaborating a single index because:

1. first of all, doses are so different that the use of two different indexes seems to be the only possible solution.
2. second but not least, Rn comes from **2 sources** (generally mainly from soil) and it is really wrong to attribute all Rn to BM.

A way to overcome these problems:

- a) establish an *a priori* reference level of Rn from BM – great help could come from a RP guide about this issue;
- b) once individuated the reference level of Rn from BM in a reasonable and scientifically based way, decision about a unique index $I_{\gamma+\text{Rn}}$ or two different I_{γ} and I_{Rn} can be taken.

Thank you for your attention

In the typical range of ρ_{brick} (700-1800 kg m⁻³) and d_{brick} (0.12 - 0.25 m) $A(\text{rd})_x$ values show large differences.

For **solid bricks** $(\rho d)_{\text{brick}} \sim 450 \text{ kgm}^{-2}$ very close to $(\rho d)_{\text{concrete}}$

➡ $A_x(\rho d)_{\text{brick}} \approx A_{x \text{ IRP112}}$

For **light-weight bricks** (perforated or hollow bricks) $A_x(\rho d)_{\text{brick}}$ values are higher, as expected by the application of room models.

