

SBE19 Graz



SUSTAINABLE BUILT ENVIRONMENT D-A-CH CONFERENCE 2019
TRANSITION TOWARDS A NET ZERO CARBON BUILT ENVIRONMENT
11 – 14 September 2019, Graz University of Technology
Rechbauerstraße 12, 8010 Graz, Austria

CONFERENCE PROCEEDINGS



IN CO-OPERATION WITH



University of Natural Resources
and Applied Life Sciences, Vienna

ETH zürich



Karlsruhe Institute of Technology

Transition Towards a Net Zero Carbon Built Environment

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WELCOME TO SBE19 GRAZ

Dear ladies and gentlemen,
Dear colleagues,

we would like to welcome you to the Sustainable Built Environment D-A-CH Conference 2019 (SBE19 Graz) - Transition Towards a Net Zero Carbon Built Environment. Together with other events in the SBE-series, the goal is to prepare for the World Conference in 2020 in Gothenburg (WSBE2020 - Beyond 2020).

The aim of SBE19 Graz is to enable an exchange between scientists, practitioners, politicians and the interested public on matters regarding innovative construction products, sustainable buildings, modern design methods and tools, sustainable urban neighborhoods and future-proof urban development. This includes new business models and instruments on green financing as well as national and regional strategies to implement sustainable development principles in the construction and real estate sector. For the first time, this regional conference has been jointly organized by institutions from Germany, Austria and Switzerland following the “D-A-CH” format.

The 145 international scientific committee members put a lot of effort into the double-blind peer review process of the scientific contributions and selected the best contributions for presentations, which are available as open source, indexed publications. 188 scientific presentations from more than 30 countries highlight the wide scope and complexity of international research activities that address sustainability issues for the built environment. The program is structured accordingly including the following topics organized in six parallel sessions: Buildings, Building Design, Processes, Products, Education & Economy and National Issues.

The matter of climate change has been stated clearly by the IPCC: Every degree of warming counts, every year of delay counts and every decision counts. It is now being increasingly discussed how the demands for climate protection can be translated into concrete design requirements, e.g. in terms of environmental budgets or environmental target values. Swift action is required and the advice of our colleagues in climate and environmental research is becoming ever more urgent. What is needed are general sustainability guidelines as well as practical solutions such as planning and assessment methods, innovative construction products and building solutions.

The role of the construction and real estate industry in developing answers to the current problems is crucial. The construction, maintenance and adaptation of the built environment is a basic prerequisite for social and economic development. On the one hand, these activities require significant amounts of energy and initiate material flows and green house gas emissions that impact the global and local environment not only during construction, but for a long time thereafter – typical lock-in factors. On the other hand buildings, cities and infrastructure are not only affected by climate change but are also expected to protect people from the undesirable effects of climate change. Therefore, the sector has multiple tasks, the most pressing one being to exploit the savings potential of the sector with appropriate support through setting suitable framework conditions and policies. Greenhouse gas emissions must be reduced to 50% by 2030 and industrialized nations must achieve net zero emissions by 2050. That is an enormous challenge, but the stakes are high and the building and related industry sector must and will contribute to the effort.

From a complex analysis perspective, topics other than mitigation should not be neglected - examples are health protection, comfort, durability, adaptability, resilience, decommissioning and recyclability (circular economy) or affordability. Frequently, this not only results in synergies but also in trade-offs, sometimes conflicting goals, which only become recognizable and solvable in an integrated, systemic approach. Methodological approaches such as technology assessment or comprehensive sustainability assessment therefore remain indispensable.

The SBE19 Graz addresses questions with additional complementary formats to the regular scientific presentations. Aspects of climate change (SDG 13) and the role of sustainable cities and municipalities (SDG 11) will be discussed in roundtable events at the pre-conference. In the special fora specific topics will be discussed in a workshop character, for example regarding LEVEL(s), CRP special requirement 7, the further development of EPDs, sustainability performance of construction products (steel, concrete, wood and plastics). Last but not least, a focus will be put on how universities and research institutes can contribute to sustainable development with their own responsibility and their own building stock – where your valuable contribution would be highly appreciated.

The days of exchange and discussion at this conference at Graz University of Technology are also an important signal: inspiring cooperation and scientific exchange across all borders is not only possible but necessary - limiting global change within planetary boundaries.

Our organizing team made a special effort to make this event itself a more sustainable one following Green Events Austria suggestions.

SBE19 Graz provides a special setting to refresh existing contacts and create new partnerships and friendships. We hope that your stay in Styria, the green heart of Austria, will stir active discussion and we are looking forward to hear your thoughts and views to progress the Transition Towards a Net Zero Carbon Built Environment.

With kind regards,
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SBE19 Graz

SUSTAINABLE BUILT ENVIRONMENT
D-A-CH CONFERENCE 2019

11 - 14 September 2019

Graz University of Technology, Austria

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PROGRAM OVERVIEW

—— Transition Towards a Net Zero Carbon Built Environment ——

Wednesday
11 September

Pre-Conference

	Aula
09.30	Welcome Coffee
10.30	SDGs & Universities
13.00	Lunch & Registration
14.00	SDG 13 Roundtable
15.30	Coffee Break
16.00	SDG 11 Roundtable
17.45	
18.30	Welcome Evening Mayor's Reception Town Hall

Thursday
12 September

Conference

	Aula	HSI	HSVI	HSXII	HSV	ATEG-152	AT01-036	AT01-104	AT01-098
08.00	Registration Conference Office								
09.00	Opening Ceremony Aula								
09.30	Keynotes Aula								
11.00	Coffee Break								
11.30	SF Level(s)	1 Buildings	1 Building Design	SF Die 3 Schwestern Alpen Bauz D22	1 Processes	1 Products	1 Education & Economy	SF CONDEREFF	
13.00	Lunch								
14.15	SF BWR7	2 Buildings	2 Building Design	1 Cities	2 Processes	2 Products	2 Education & Economy	SF ecoinvent	SF vinylplus
15.45	Coffee Break								
16.15		3 Buildings	3 Building Design	2 Cities	3 Processes	3 Products	3 Education & Economy	SF EPD	
17.45									
18.00	Guided City Tour From the conference venue to the Schlossberg								
19.30	Conference Dinner Schlossberg Restaurant								

Friday
13 September

Conference

	Aula	HSI	HSVI	HSXII	HSV	ATEG-152	AT01-104	AT01-098
08.00	Registration Conference Office							
09.00	ADOPTION OF THE "GRAZ 2019 DECLARATION" Aula							
09.20								
09.30	1 National Issues	4 Buildings	4 Building Design	3 Cities	4 Processes	4 Products	SF Beton	SF Plastics
11.00	Coffee Break							
11.30	2 National Issues	5 Buildings	5 Building Design	4 Cities	5 Processes	5 Products		
13.00	Lunch							
14.15	3 National Issues	6 Buildings	6 Building Design	5 Cities	6 Processes		SF Holz- system- bau	SF Smart City Graz
15.45	Closing Event including <i>Best Paper Award</i> Aula							
17.15	Farewell Coffee							

Saturday
14 September

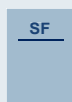
Side Event

09.30	
12.00	Technical Tour
15.00	
15.30	

Thursday 12 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-036	AT01-104	AT01-098
08.00	Registration Conference Office								
09.00	Opening Ceremony Aula								
09.30	Keynotes Aula								
11.00	Coffee Break								
11.30	SF Level(s)	1 Buildings	1 Building Design	SF Die 3 Schwestern Aspern Bauplatz D22	1 Processes	1 Products	1 Education & Economy	SF CONDREF	
13.00	Lunch								
14.15	SF BWR7	2 Buildings	2 Building Design	1 Cities	2 Processes	2 Products	2 Education & Economy	SF ecoinvent	SF vinylplus
15.45	Coffee Break								
16.15		3 Buildings	3 Building Design	2 Cities	3 Processes	3 Products	3 Education & Economy	SF EPD	
17.45									
18.00	Guided City Tour From the conference venue to the Schlossberg								
19.30	Conference Dinner Schlossberg Restaurant								



Special
Fora



SF in
German
language



Conference
Sessions



Special
Sessions

Friday 13 September

Conference

	Aula	HS I	HS VI	HS XII	HS V	ATEG-152	AT01-104	AT01-098	
08.00	Registration Conference Office								
09.00	ADOPTION OF THE "GRAZ 2019 DECLARATION" Aula								
09.20									
09.30	1 National Issues	4 Buildings	4 Building Design	3 Cities	4 Processes	4 Products	SF Beton	SF Plastics	
11.00	Coffee Break								
11.30	2 National Issues	5 Buildings	5 Building Design	4 Cities	5 Processes	5 Products			SF
13.00	Lunch						13.30		green.LAB Wagner-Biro-Straße
14.15	3 National Issues	6 Buildings	6 Building Design	5 Cities	6 Processes		SF Holzsystembau	SF Smart City Graz	
15.45	Closing Event including <i>Best Paper Award</i> Aula								
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Seismic and solar performance of historical city

Urban form-based multicriteria analysis

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Abstract. The understanding of the global performance of a historical city is a complex balance of several specific issues and requires a multi-disciplinary approach to face with actual urban phenomena and challenges, such as the seismic risk and energy efficiency, that are strongly influenced by urban form. This paper focuses on the potential of urban metrics and typological indicators for describing the seismic vulnerability and the solar radiation availability of distinct urban textures, and the correlation between the two aspects. Comparative analysis at fabric scale was conducted on the historical centre of Rieti (Latium, Italy), to underline the main seismic and solar indicators. In the last decade, we witnessed the spreading of urban scale assessment and analysis tools, but seldom using an integrated approach to face the complexity of the historical city. Relying on morpho-typological indicators, the proposed method characterizes the fabrics in terms of seismic vulnerability and solar availability through a multicriteria analysis. The analysis reveals substantial differences between fabrics using three groups of indicators: *Plan*, *Space* and *Analysis-oriented*. Each group describes different features of the urban fabrics that affect seismic and solar performance and suggests improvement strategies. The purpose is to support policymaker and designer in the urban renovation process.

1. Introduction

The historical city is a complex system, and the understanding of its evolution requires specific attention to face urban actual phenomena and challenges, as natural disasters and climate changes. Nowadays, several studies in the field make use of approaches at the urban scale, rather than the building scale, in order to consider and explore all the elements that affect the functioning of a city [1–4]. Moreover, different urban forms correspond to different performances among which the seismic and the solar performances must resort to the analysis of the physical features of basic components of the built environment. In this framework, our study explores the causal relation urban form/seismic vulnerability/solar energy in the historical city through a multicriteria analysis, based on physical indicators - Urban Metrics (UM) and Morpho-Typological Indicators (MTI). The aim is to ease planning decisions for sustainable renovation processes.

The Mediterranean city represents a significant example of urban system, based on masonry construction and characterized by typological processes of growth, closely related to climate conditions and seismic events that defined its history. In terms of seismic risk, the analysis of the urban fabric focuses on the mechanical behaviour at the scale of the building aggregate [5], defined as a complex system of interrelated parts, structural units that are interconnected or in contact, which may interact

under a seismic or dynamic action in general. Building aggregates generally have non-homogeneous and stratified constructive features, with different level of effectiveness of structural links between different parts. The research aimed at understanding the seismic performance of the city has developed the following approaches: on the one hand the structural-constructive approach focused on the analytical-mechanical understanding of masonry construction [6,7] and the identification of constructive characteristics linked to the reduction of vulnerability on an urban scale [1,2]; on the other hand the urban-systemic one [8,9] focused on risk assessment for the functional systems in which the city is organized. The shift of attention from the scale of the building to the aggregate and urban fabric one revolves around the morpho-typological parameters, which together with the constructive ones, are the basis for expeditious assessments of vulnerability on the urban [2,10] and territorial scale [11].

Solar energy availability is a key variable to assess buildings energy performance in the urban environment. On one hand, building's solar gains account for a significant part of the energy balance during both winter and summer; on the other hand, the potential for harvest solar energy in the urban context is directly connected to the potential for renewable energy systems to enhance energy efficiency at urban scale. Several studies reported the effect of urban metrics on solar performance [12,13]. Some of them consider real urban areas and related data in order to predict their solar potential using UM to better characterize the layout of the case studies [14,15]. Other studies focused on understanding the influence of urban morphology, described and controlled through UM, to optimize the solar potential of urban areas. The latter use normalised models derived from representative urban textures [16,17]. To perform solar energy analysis at urban scale, experts use specialised tools recently developed for the purpose, i.e. *Radiance*, *DIVA*, *CitySim* and *SUNtool*. These tools fostered the implementation of solar analysis in design practice. However, two factors still limit their widespread to urban planning and design: the specialist knowledge required to set up the simulation and the amount of time needed to realize the model at urban scale. For these reasons, this study uses the capability of UM to predict solar energy availability at urban scale. The method, based on a previous study reduces time and data necessary to carry out solar analyses, useful in the early stage of the design process [18]; this method is intended for architects and decision makers since do not require specialist knowledge and data required for the calculation are generally used in urban planning practice and are easily accessible for many cities.

In the last years, the importance of integrated approaches between energy and seismic analysis is testified by a growing number of studies. The relevance is particularly highlighted regarding the retrofit of the built heritage, implementing building envelope systems for energy, structural, and user-oriented retrofit that would significantly increase the commercial value and the life cycle of buildings, involve the users in attractive and visible solutions and, reduce the costs of energy [19]. Other studies regard the renovation of a high-rise building, focusing on the architectural quality to demonstrate the cost-effective evaluation of the convenience of the integrated approach in supporting public administration in social housing renovation [20]. On the one hand, the importance of the urban scale is nowadays recognized and investigated in several types of research for both the energy and the seismic performance, focusing the influence of urban morphology on these features [21]. On the other hand, the integration of the approaches is still focused on the building scale. The aim of this research paper is to overcome this compartmentation of knowledge, proposing a preliminary approach on integrated multicriteria analysis for the historical city, based on morpho-typological indicators in order to describe the seismic vulnerability and the solar radiation availability.

2. Methodology

2.1. The city of Rieti

The city of Rieti, located in Central Italy, is the ideal urban environment to test seismic and solar performance of historical urban form. Rieti concerned with the category of medium sized (between 5,000 and 60,000 inhabitants) local council areas, which make up about 30% of the total of Italian local government bodies and concern over 50% of the population - Ancitel on Istat database (01/01/2018).



Figure 1 Aerial view of the city of Rieti and case studies identification.

The municipality of Rieti is characterized by well-conserved historic centre covering an area in proportion to its population and which falls in an area of medium-high seismic risk (zone 2), the area recently stroke by the 2016 Central Italy Earthquake. Case studies are three representative aggregates of typical urban texture of Rieti: case **I** is located in the core of the roman town, following the ancient settlement, along the *decumanus*; the aggregate, as a portion of an urban texture characterized by a clear hierarchy of streets and public space, is the result of stratification and alteration of the original seventieth century buildings; case **II**, close to the medieval walls, is part of a more articulated urban fabric with narrow streets; case **III** is located in the first medieval expansion, with a regular street pattern and mainly based on row houses, partially modified or replaced in recent times.

2.2. Metrics for urban form analysis

The range of variation of several Urban Metrics (UM) and Morpho-Typological Indicators (MTI) have been calculated. The formers have been derived from three-dimensional models of the urban textures with a level of detail LoD1 [22]. The latter have been derived from typological-observational methods, based on data of damage and vulnerability observed on previous earthquakes and normally calibrated on the use of existing databases with a level of accuracy 1 [7]. The UM taken into account have been derived from eight basic variables, widely common in urban and building studies and easily accessible (Table 1). Each metric gives information on some qualitative aspects of the urban form, such as the shape of the buildings, the plot patterns or the street network. It has been already proven that UM have a causal relation with energy performance at the urban scale [3,23]. Morpho-typological indicators are derived from the observational approach on the damage of similar structures, common in vulnerability studies for expeditious assessment at urban and territorial scale. Each indicator gives information on some qualitative aspects of the urban form and structural behaviour of the aggregate, such regularity of shape, interactions with existing buildings, transformations and interventions (Fig. 2 Table 2). The MTI analyzed are derived from the studies conducted on the case study of Nocera Umbra [24] and from the studies of Borri and Avorio, carried out on the masonry construction. In analogy with Fazzio's studies [24], qualitative indicators have a variable weight ranging from 3 to 10.

Both UM and MTI have been divided into three groups, considering their peculiarities in describing urban form: *Plan*, *Space* and *Analysis-oriented*. Besides, in order to facilitate the understanding and of the results, a comparison between cases has been conducted by means of normalization (Table 2). The groups collect UM and MTI with similar properties in terms of description of different features of the aggregates: *Plan* indicators are able to represent the main features on the horizontal plan; *Space*

indicators describe the three-dimensional complexity; *Analysis-oriented* indicators are useful to predict solar and seismic performance at early stage of analysis.

2.3. Aggregate seismic and solar performance

The "vulnerability of the aggregates" is defined as the susceptibility to damage and loss of organization due to the complex of risk factors to which individual blocks are subjected, deriving from typomorphological, structural and functional aspects [24]. In this study, we refer to "relative vulnerability" of the aggregates, because the normalization is carried out on the dataset of each city. Given the typological-observational nature of the vulnerability assessment methodology, the results have a greater relevance for the urban management in order to understand the vulnerability level of different portion of the urban texture.

Analogous to the cited studies, the seismic performance has been analysed through two groups of indicators, as part of a wider research [10]: descriptor parameters of the morphological and typological characteristics of the aggregate, related to the overall configuration; descriptor parameters of the general structural characteristics, related to the average characteristics of building components and aggregation methods. In this paper the first group of indicators have been considered (Figure 2).

The solar irradiation on building façades has been assessed for the selected urban aggregates of each digital model, considering urban obstructions during the whole year. We focus on the solar performance of the vertical surfaces since they are directly related to the building's solar gains which account for the most part of the energy demand in the Mediterranean latitudes. *Heliodon2* software and *Heliodon2plus* data post-processor have been used for simulations. *Heliodon2* calculates the spatial and temporal distribution of solar energy on building façades, considering a cloudless sky condition during a given period; the associated post-processor uses climate data to obtain direct and diffuse solar radiation. Calculations have been carried out on the basis of the latitude of the city of Rieti (42°24' N 12°51' E).

3. Results and discussion

The main results, with regards to solar irradiation on building façades and seismic performance, UM and TI evaluation are here presented and discussed in two separate subsections. The results have general implications to seismic and solar performance at urban scale in the historical city of Mediterranean climate.

3.1. Seismic and solar performance

The assessment of seismic vulnerability for the aggregates shows the most critical situations for the cases with higher *Sd* or *TAd*, which is usually reflected also on articulated geometric configurations (**I**), and for irregular aggregates with high values of *PT*, *PTis* and *AT*, located in complex urban fabric. The latter due to the relation with the surrounding aggregates (*rSA*) increasing the induced vulnerability (**II**). On the contrary, case **III** emerges as relatively less vulnerable as described by lower *PT* (regular linear trend) and lower *TAd* (mainly composed of building with a high degree of typological homogeneity). In order to complete the seismic analysis and to evaluate the relative vulnerability index, indicators based on structural characteristics are reported in Table 3.

Table 1 Urban metrics basic variables.

Symb.	Unit		I	II	III
P	[inhab.]	Population	646	382	374
A	[m ²]	Base land area	5362	3482	4396
C	[m ²]	Footprint	3693	2288	3117
F	[m ²]	Gross floor area	15095,4	9222,64	9817,41
S	[m ²]	Façade surface	10216,5	7131,4	5711,2
V	[m ³]	Built-up volume	64571	38236	37403
Li	[m]	Interior network	0	0	0
Le	[m]	Edge network	325	266	377

Table 2 Values of morpho-typological indicators and urban metrics regarded to case studies.

Plan			I	II	III
FSI	[m ² /m ²]	Building intensity	2,82	2,65	2,23
FSd	[inhab./m ²]	Floor space density	0,04	0,04	0,04
GSI	[m ² /m ²]	Coverage	0,69	0,66	0,71
N	[m/m]	Network density	0,030	0,038	0,043
OSR	[m ² /m ²]	Open space ratio	0,111	0,129	0,130
PT	adim.	Planimetric Trend	7	10	3
PTis	adim.	Planimetric Trend Interruptions	7	10	7
Space					
Vd	[m ² /m ²]	Vertical density	1,91	2,05	1,30
VOSR	[m ² /m ²]	Vertical open space ratio	6,12	5,97	4,47
VAr	[m ³ /m ²]	Volume-Area ratio	12,04	10,98	8,51
rSA	adim.	rapport with Surrounding Aggregates	7	10	7
rTM	adim.	relation to the Territory Morphology	3	7	3
AT	adim.	Altimetric Trend	7	7	3
MVld	adim.	Mountain-Valley levels difference	7	7	3
Analysis-oriented					
TCI	adim.	Typological Commingling level	5	5	3
STS	adim.	presence of Specific Typological Structures	7	5	5
TAd	adim.	Typological Alteration degree	10	5	7
Sd	adim.	Stratification degree	10	5	7
SF	adim.	Sky Factor	25,2	22,0	30,2
SVF	adim.	Sky View Factor	21,4	19,0	24,7

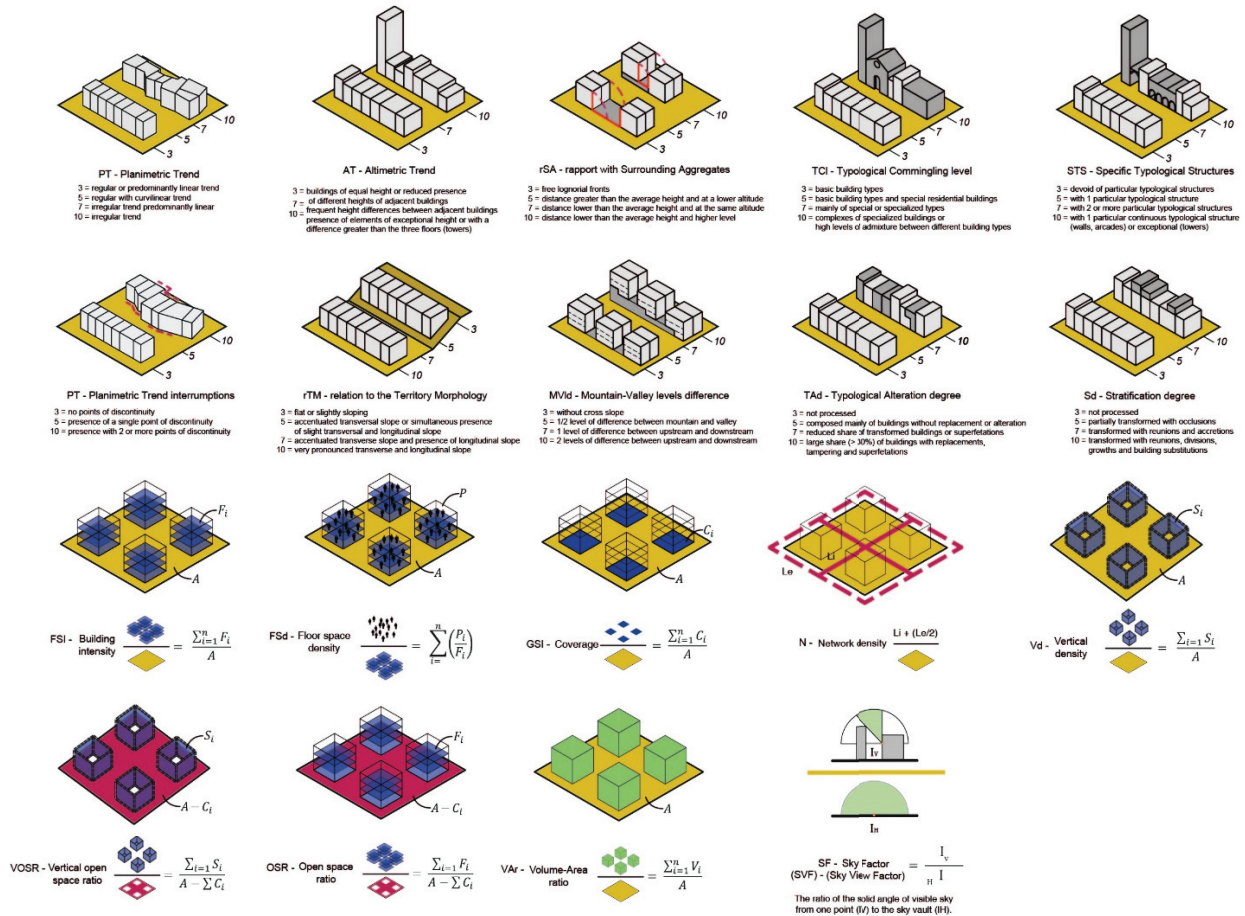
**Figure 2** Description of morpho-typological indicators (MTI) and urban metrics (UM).

Table 3. Structural characteristics parameters and total values, TI total values and vulnerability index.

	I	II	III
Average conservation status of vertical structures	5	3	3
Average conservation status of horizontal structures	5	3	3
Average state of conservation of the roofs	5	3	3
Synthetic index of masonry quality	7	7	7
Presence of particular structural elements	5	5	0
Offset of floors between adjacent buildings	7	7	10
Slenderness of the wall	3	3	3
Pushing elements (arches, vaults, roofs)	7	10	7
Masonry discontinuities	7	7	5
Discontinuities or singular elements in vertical structures	1	5	1
Discontinuities or singular elements in horizontal structures	1	5	1
Discontinuities or singular elements in roof structures	1	5	1
Regularity in the arrangement of openings	3	3	7
Total indicator of structural characteristics	57	66	48
Total TI	70	71	51
Overall vulnerability index	127	137	99
Overall vulnerability index (normalized)	8	9	3

Table 4 Value of solar energy over a one-year period regarded to case studies.

	Unit	I	II	III
Solar radiation	kWh*	2.748.809	2.283.577	2.107.196
Façade energy density	kWh/m ² *	269,1	320,2	369,0
Direct solar radiation	kWh	662.113	550.052	507.566
Diffuse solar radiation	kWh	1.315.029	814.776	850.469
Global solar radiation	kWh	1.977.142	1.364.828	1.358.035
Direct façade energy density	kWh/m ²	64,8	77,1	88,9
Diffuse façade energy density	kWh/m ²	128,7	114,3	148,9
Global façade energy density	kWh/m ²	193,5	191,4	237,8
Direct solar radiation fraction		33%	40%	37%

* Considering cloudless sky condition

Concerning solar energy, irradiation on façades (kWhm⁻²y) is directly related to a combination of high-density-related values (GSI, VOSR, Vd) and low SF/SVF values. In historical urban textures, reasons for better solar access compared to observed tendencies, are due to specific morphological features: lower urban density combined with optimal façades orientation (III). Instead, solar performance is in general poor for cases with high urban density (as described by each UM). Even though similar surface exposure and lower SF/SVF, case II receives more solar radiation compared to I. This result is reliably represented by UM (FSI, GSI, VOSR and VAr). Comparing fractions of direct and diffuse irradiation for case studies, we notice that differences between I and III are almost levelled by increasing of diffuse radiation (Table 4). Based on these results, it can be argued that, considering the most reliable metrics for solar analysis as indicated in previous studies [18], II and III performs better than the average. The former, due to the presence of several courtyards and higher ratios of façade surface/built volume. The latter thanks to favourable texture orientation in relation to façade exposure.

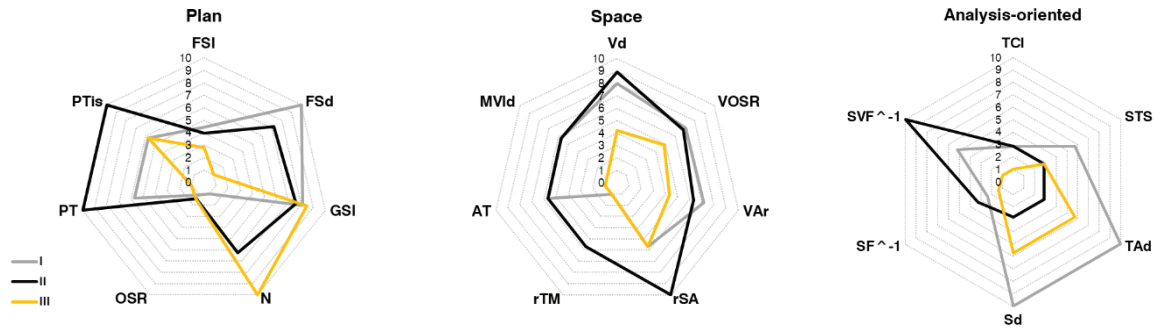


Figure 3 Comparison of normalized UM and MTI (grouped into Plan, Space and Analysis-oriented)

3.2. Urban form metrics and typological indicators

Table 2 and Figure 3 show respectively the computation of UM and MTI and the corresponding normalized values for case studies (decimal scale). The purpose of the diagrams is to visualize the urban scale performance: the higher the value of an indicator, the worse the behaviour of the aggregate in term of solar availability and seismic vulnerability. For this reason, we use reciprocal value for SF and SVF. In general, to combine different indicators helps clearly understand building density and compactness of urban fabric: compared to cases **I** and **II**, we can observe that case **III** is more compact and have less building intensity, producing openness in the urban form. By grouping different types of UM and MTI is possible to highlight urban form features of each case as shown in Figure 3. Case **III** values clearly reflect differences in urban layout and morphology of the island. Moreover, the difference between **I** and **II** appears: **II** has higher values in most of the *Plan* and *Space* metrics, while **I** has higher values in all the *Analysis-oriented* metrics. The case **I** and **II** are the aggregates with lower performances, while case **III** always covers the smaller areas of the graphs, showing as in a regular urban texture exist more favourable condition.

First-stage evaluation of seismic vulnerability and façade solar availability at urban scale can be obtained making use of the diagrams: the smaller the area on the proposed diagrams, the greater are the intrinsic capacities of the urban aggregate to perform at both levels.

4. Conclusion

Our paper presents an investigation on the capability of a multi-criteria analysis based on UM and MTI to predict urban seismic vulnerability and solar availability in the historical city located in Mediterranean climate. The Plan indicators highlight intrinsic criticalities of urban texture regarding the horizontal plan, therefore strictly related to urban form and very hard to transform without invasive action that could compromise the historical value. The Space indicators, due to their three-dimensional definitions are suitable to describe renovation strategies based on urban acupuncture and geometric regularity, taking into account the interaction with the urban surroundings. The Analysis-oriented indicators are suitable to control urban form and typology implications of solar and seismic performance and to improve them through solar and seismic sensitive design.

The proposed multi-criteria analysis model has been structured with several purposes. On one hand, it can support policy maker decisions according to the performances of urban aggregates, in order to differentiate public investments and incentives; on the other hand, it should be integrated in the early stage of design process, taking into account the solar façade availability and seismic vulnerability of urban areas to guide urban renovation strategies.

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