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Editorial

Advancements in Design and Analysis of Protective Structures

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The objective of this ADAP Special Issue volume is to provide an overview on the current trends and recent advancements in terms of design and analysis, including experiments and modelling, on protective structures.

From a structural point of view, such a definition includes multiple loading and boundary conditions that designers should be properly accounted when ensuring appropriate safety levels to people. In fact, protective structures and facilities are expected to optimally perform their function under severe loads, even when associated with mostly different threats. Extreme events like earthquakes, fire accidents, explosions (even nuclear), and high-rise natural hazards are the first reason of severe damages in constructed facilities and causalities. Impacts due to collisions of transportation means, on the other hand, should be also properly accounted when designing bridges or containment structures in general. A key role, in all the mentioned cases, is given to design optimization and mitigation of input forces/effects. Such a result can be achieved by both reducing the magnitude of applied loads on structures, that is, via active, passive, and semiactive additional devices, and by enhancing the structural resistance and capacity, that is, via efficient materials and structural components.

Within a more general definition of protection and protective tools to improve security, different means are indeed accepted, being possible to achieve the final protective goal at the emergency management level rather than at the material/structural level only, hence suggesting a cooperation of multiple aspects and expertise.

In doing so, finite element (FE) and computational fluid dynamics (CFD) numerical simulations, as well as full-scale experiments and analytical models, can represent valid tools for the analysis of emergency and hazard conditions.

The revised papers included in the final ADAP Special Issue booklet are related to various topics, including studies at the management, material, and assembly levels, under a multitude of loads.

In the paper from Larcher et al., security enhancements against terroristic attacks or explosive events in general are suggested for vulnerable areas via the use of protective wall systems. Such a strategy concept, numerically investigated by the authors by taking into account internal blast scenarios and access control points, relies on the prevention of blast wave propagation within a given building. The efficiency of rigid (meandering) walls is explored by taking into account a case study building system, giving evidence of their active contribution as effective risk-reduction measure.

As a preliminary requisite, protection of people in buildings under emergency scenarios should in fact generally account for appropriate evacuation plans and strategies. Congestion, as highlighted by Zhao et al., actually represents the major cause of crowd trample and crushing incidents. Shunt walls, in this sense, can also enhance the safety levels for pedestrians and occupants but should be properly designed via evacuation simulations, especially to account of large crowds.

Containment walls can be efficient within buildings but also for the minimization of transportation accidents, as in the case of trains, being typically associated to tragic scenarios when derailment and collision incidents occur. To this aim, refined 3D simulations are presented by Bae et al., to explore the impact configurations due to high-speed train

derailments, including various loading configurations. Possible recommendations to take into account in the design of containment walls or blocks are also provided, based on parametric studies.

Within the variety of "extreme" hazards that buildings and infrastructures should properly withstand, major threats often derive from explosions and high-strain impacts.

Bridges and tunnels can be potential targets of terroristic attacks since their collapse or severe damage is often associated with possible causalities, economic disaster, and panic scenarios. In this regard, protection of bridges to blast loads has attracted the interest of a large number of research studies, during the last years. In the paper by Yao et al., the dynamic performance of steel box girders is numerically investigated under the effects of internal explosions, by taking into account several scenarios. Through the parametric study, evidence is given to the typical local failure phenomena leading the box girders to collapse, including design suggestions to enhance their blast-resistance capability.

Optimal tendon profiles are suggested by Aleyaasin for posttensioned steel box girders, to optimize their structural performance and resistance, aiming to properly withstand accidental blast loads due to car bombs. A design method is also proposed and validated via a case study example.

Protection of bridges can also be required against different sources of hazards and accidents, as reported in the paper by Wang and Morgenthal, where the pier performance under barge impacts is investigated. A novel crash-worthy device, being representative of a sacrificial steel structure to mitigate high-rise impact effects on piers, is assessed and optimized, including a worked example. Major benefits of such a crash absorber derive from its large energy-dissipation capacity during impact, hence minimizing the forces that the piers should actually withstand.

In the paper by Ghaedi et al., the seismic performance of adjacent, base-isolated buildings with segregated foundations is explored via nonlinear time history analyses. Numerical simulations are reported to give evidence of the actual seismic performance of adjacent buildings with base isolation, with respect to fix-base solutions, as well as to emphasize the potential and benefits of base isolation, as a function of different separation gaps and input features.

The analysis of structures under extreme loads requires an accurate definition of loading scenarios. In this regard, Pathak and Ramana report on a closed-form expression for the estimation of nuclear air-blast-induced free-field ground displacements, by accounting for several key input parameters. The analytical model is validated against available nuclear test data, giving evidence of the potential of the mathematical formulations and including possible recommendations for design calculations.

Especially under extreme events, connections and details can have a key role for the global performance of a given system. This is the case, for example, of buildings under seismic loads (where governed damage and failure mechanisms should be preferred), and especially for prefabricated structures, where the structural interaction between the independent members can be crucial.

Sun et al., in this regard, explore a rabbet-unbond horizontal connection (RHC) for new reinforced concrete, prefabricated shear walls. Full-scale tests are reported, including discussion on the structural performance of the walls and damage propagation. Compared to conventional connection systems in use for the prefabricated systems under investigation, the presented RHC solution takes advantage of unbonded reinforcement to enhance the ductility capacity and energy dissipation of the so assembled structure. Even in presence of a limited number of test results, major effects and benefits are observed on the ultimate displacement of RHC specimens, with variations on the expected ductility ratio, hence suggesting further extended investigations.

The use of innovative materials and their optimal combination can have important effects for structural performance optimization approaches, both for the retrofitting of existing assemblies as well as for the design of novel constructions. In the first case, experimental studies are proposed in the paper by Ghai et al., where the authors report on the structural efficiency of polymer-modified ferrocement (PMF) jacketing technique for reinforced concrete beams in shear, by using styrene-butadiene-rubber (SBR) latex polymer. Even in presence of shear failure mechanisms in RCC beams typically associated with a combination of multiple aspects (such as load pattern, shear-to-span ratio, beam section, concrete strength, reinforcement type, and amount), Ghai et al. show that the PMF jacketing technique can improve the deformation, crack pattern, and ultimate shear load carrying capacity of initially damaged beams, hence representing a valid strengthening solution.

Deng et al. present uniaxial compressive tests on high ductile fiber-reinforced concrete (HDFRC), including the proposal of a damage constitutive model. Comparative results show the accuracy of their HDFRC damage evolution model, as well as the key role of fibers at the cracking stage.

Hake et al. investigate the temperature effects on lime powder-added geopolymer concrete. Different lime powder amounts are taken into account, giving evidence of the actual compressive resistance of concrete specimens as a function of different temperature scenarios.

Thermal loads in general can have crucial effects on most of the materials in use for buildings and infrastructures, hence requiring careful consideration to ensure appropriate safety levels. This is especially the case of structural systems under fire loading, where multiple aspects should be accounted at the design stage. In this regard, a state-of-the-art review is finally by Bedon, to assess the mechanical performance of structural glass systems and assemblies in fire conditions. Key aspects for their analysis and behavioral assessment are reported from the literature, giving evidence of material sensitivity to high temperatures, as well as presenting a summary of existing research studies at the small/full-scale levels, and including some general considerations on current design issues.

In conclusion, let us have some final considerations on this ADAP Special Issue project.

First of all, all the contributing authors are gratefully acknowledged for their support. The hope is that the readers

could find fruitful and high-quality research topics in the published papers.

Peer reviewers are also gratefully acknowledged for their hard work, ensuring the publication in this volume of high-quality scholarly journals. A final acknowledgement is also extended by the Lead Guest Editor to the full team of Guest Editors, for the support provided in the last months through the full process of submission and promotion of the call for papers, up to the publication of the ADAP Special Issue booklet in *Advances in Civil Engineering*.

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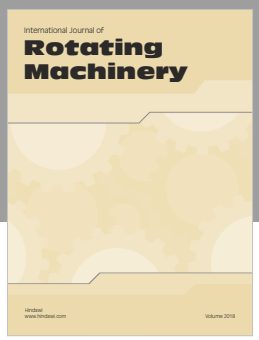
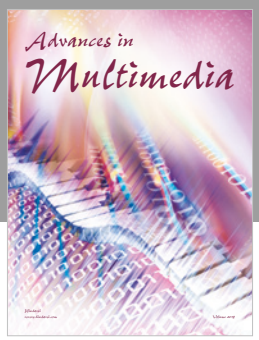
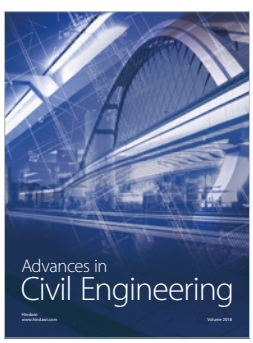
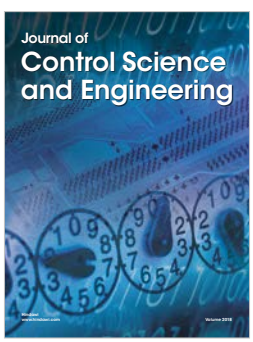
Michel Arrigoni
Filipe Santos
Lucia Figuli









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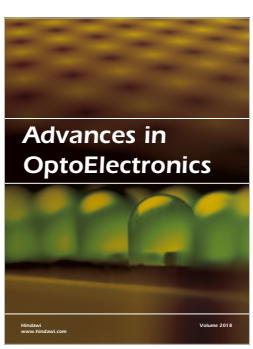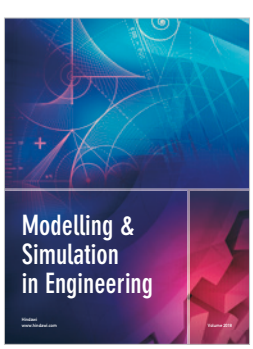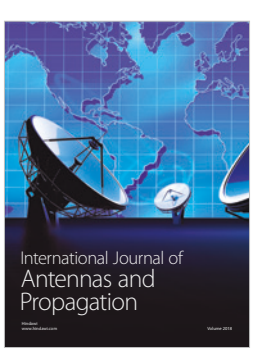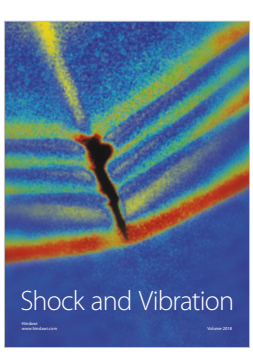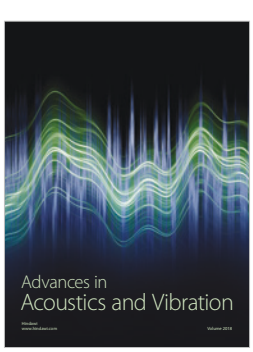
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