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DESIGN FOR SURVIVAL

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Emergency frame

Universal Design proposal to improve safety levels of urban building

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Il mondo è costantemente testimone di un aumento della popolazione urbana e, di conseguenza, delle problematiche connesse alla gestione dei rischi di varia natura. Questo contributo esamina diversi metodi possibili per migliorare i livelli di sicurezza delle abitazioni e propone una soluzione progettuale universale; capace ossia di includere persone anziane, genitori con figli, donne in stato di gravidanza, persone con animali domestici e tutte le possibili condizioni di mobilità limitata (permanente, temporanea o situazionale). La ricerca, in particolare, si concentra sugli edifici residenziali di media altezza e propone una soluzione basata su un approccio innovativo alla multifunzionalità. Viene presentato il concept di un sistema a basso impatto per gli edifici esistenti, caratterizzato da accessibilità, funzionalità e fattibilità industriale.

Emergenze urbane, Sistemi di fuga dagli edifici, Design for All, Design multifunzionale, Design a basso impatto

The world is constantly witnessing an increase in urban populations and, as a consequence, in matters related to the management of various risks. This contribution examines different possible methods to improve dwellings safety levels and proposes an universal design solution. It means to include elderly people, parents with children, pregnant women, individuals with pets and all possible conditions of physical limitation (permanent, temporary or situational). The research in particular focuses on mid-rise residential buildings and propose a solution based on an innovative approach to multifunctionality. As a result, a concept for a low-impact system for existing buildings is presented, based on accessibility, functionality, and industrial feasibility.

Urban emergencies, Escape systems, Design for All, Multifunctional design, Low-impact design

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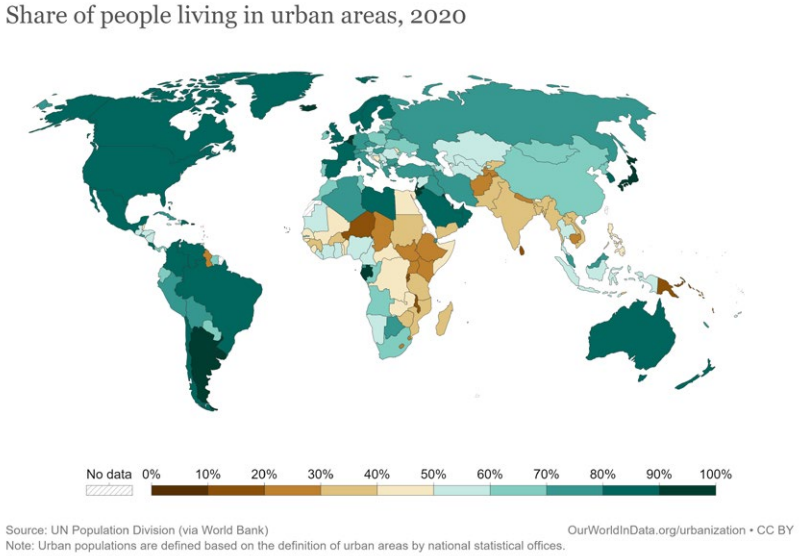
Introduction

The world we live in is filled with unexpected emergencies that cannot be predicted or totally avoided. Due to the increased incidence of extreme weather events (Brooks 2003, Kumar, 2021) and human-made hazards related to accelerated urban growth (UNISDR 2012), urban areas are specifically threatened and should therefore be the priority target of possible preparedness' actions. However, assessing the risk and vulnerability of an urban area is a very demanding task, requiring not only considerable technical knowledge but also an amount of human and financial resources that are usually not totally available (Julià an Ferreira, 2021). "Residential emergencies" refers to all kind of situations which may result in significant bodily injury or death to the occupants of a building. It is vital that quick decisions are taken in the event of an emergency; minutes and even seconds can make the difference between life and death. Any situation, regardless of whether it is a natural disaster or a man-made one, should be prepared for at all times. To acquire a higher level of general occupants safety, it is necessary to take into consideration a variety of disasters that can occur, including earthquakes, fires, gas leaks, explosions, chemical spills, violent acts, and bomb threats among many others (OECD, 2017). Ideally, it is advisable to prepare a plan before these events occur in case there is a crisis that arises as a result of these events (Xu and Tianyan, 2021). There are not many possible ways to escape from a building in the event of an emergency; however, when we discuss escape, the first thing that comes to mind is the emergency staircase. In the case of individuals with vulnerabilities or disabilities, traditional escape methods are almost never effective. In times of emergency, safe egress and communication are essential to ensuring the safety of everyone. The majority of people can decide on and find escape routes from a building without difficulty, but in more severe situations, such as fragile people with physical and cognitive limitations, or buildings of the early modern or the mid-century era, modern escape equipment may not be able to support people. There has been a recent increase in awareness among emergency departments that current escape procedures may not always be effective in terms of escaping or securing the lives of people who are stuck in an emergency situation (Cimellaro, 2016).

Aims and methodology

The research here is presented is aiming at analyzing the questions of occupant escaping from buildings in emer-



01

gency situations by a Human-centred Design perspective, in order to conceptualize a new multifunctional component able to respond to occupants human-centred needs during emergency situations.

In methodological term, the Design for All for communities approach has been adopted (Attaianese et al. 2022), structured into two macro phases. The first aimed at outlining research questions and the cultural and use reference framework for the identification of human needs and human centred requirements, that include the study of user targets in terms of human variability, the context, as well as the selection of significant design experiences, through which to implement the collection of reference data useful for the concetualization of the intended system. The second macro phase is aimed at translating the human-centred requirements into project specifications, according to an iterative trial-and-error process, aimed at verifying and progressively modifying the characteristics of use hypothesized for the system (simulated with virtual prototypes and real mock-ups) in relation to the targets. In both macro-phases, the systematic application of task analysis methodologies allow to prefigure, and then verify, the levels and modalities of human interaction that the hypothesized system develops.

01
Percentage of people living in urban areas by 2022, with this data we can see most of world is urbanized. Source: https://ourworldindata.org/urbanization#share-of-populations-living-in-urban-areas

Macro-phase 1. Observations about the use context

Observation 1: urban living scenarios and trends In 2018, an estimated 55.3 per cent of the world's population lived in urban settlements. By 2030, urban areas are projected to house 60 per cent of people globally and one in every three people will live in cities with at least half a million inhabitants (United Nations, 2018). It is estimated that in 2050 the share will even be 68% of the total. Cities across the world are becoming increasingly urbanized and, going on with this trend, urban populations will grow to two-thirds by 2050. Unplanned, rapid urbanization can cause social instability, infrastructure risks, and natural and man-made disasters (OECD, 2017). Risks increase with the unpredicted move to urban areas. Of the 1,146 cities with at least 500,000 inhabitants in 2018, 679 (59 per cent) were at high risk of exposure to at least one of six types of natural disaster, namely cyclones, floods, droughts, earthquakes, landslides and volcanic eruptions. Taken together, cities of 500,000 inhabitants or more [fig. 01] facing high risk of exposure to at least one type of natural disaster were home to 1.4 billion people in 2018 (United Nations, 2018).

Observation 2: choosing the building Based on the height of a building, it is possible to analyze the main typologies of building we generally found in cities (United Nations, 2018). It has become increasingly common for apartment

02

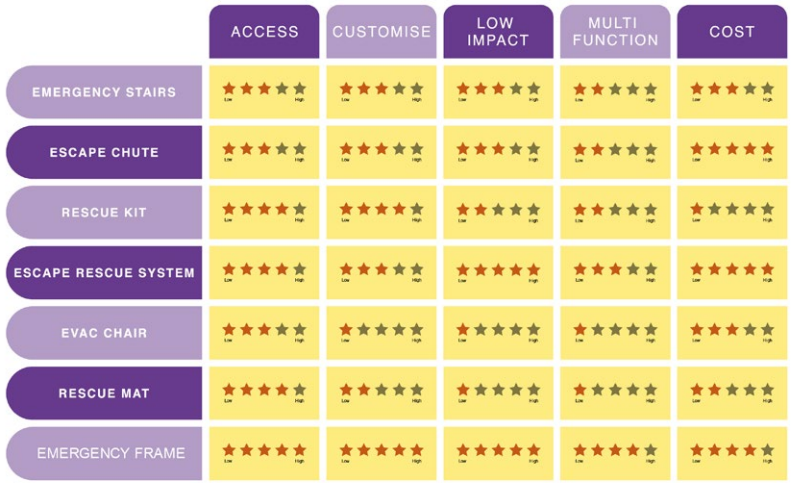
02
Information on the percentage of low-rise, mid-rise, and high-rise buildings occupied in various cities by 2018. Source: https://www.rentcafe.com/blog/apartmentliving/high-mid-rise-residential-buildings-overshadowing-low-rise/

buildings to be built in mid-rises and high-rises [fig. 02]. There has been a steady decline in the number of low-rise buildings in the city since 1999, while the number of mid-rise and high-rise apartment buildings has steadily increased during the same period. Today the majority of buildings worldwide are mid-rises and today there is need to improve safety levels of these buildings in cities since they generally are not flexible enough to respond to emergencies (OECD, 2017).

03

03
A comparison of the populations for the years 2010, 2020, and 2030 can be seen in the following three graphs. Source: demographic-trends/are-young-people-living-in-our-cities-for-longer/

Observation 3: user groups To understand the needs and problems faced by different users, this study examines how emergency situations in city buildings could affect different age groups [fig. 03]. Identifying these "wider" vulnerabilities is the first step in understanding the key factors that are the inputs for a design process aimed of really inclusive emergency safety solutions. Our global population is getting older, largely because of increasing life expectancies and declining birth rates. In 2020, more than 147 million people around the world were between the ages of 80-99, accounting for 1.9% of the global population. In general, this means that in the near future it is growing the probability to have inhabitants of urban dwellings that are expected to be slower and slower, weaker, sick. Beyond that, to define the user target in a really universal way, it is important to include in the design process all the possible conditions of mental or physical limitation (Patel et al, 2017). These conditions can be permanent (for example in the case of disabled people), temporary (pregnant women, illnesses or injuries due to the emergency itself) or simply situational (pet owners, parents with a child, people in unexpected panic condition). The ambition of the research is to create, overall in emergency situations, solutions that are physically, cognitively, and emotionally appropriate for all kind of users. This design sensibility starts with seeing human diversity as a precious resource to reach solutions able to save more life as possible (Attaianese et al, 2021).

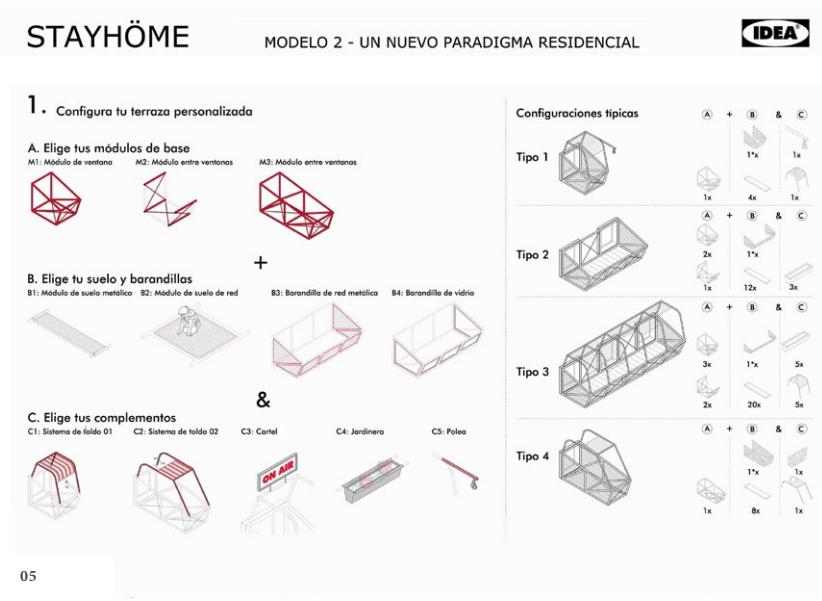


04

04
Comparative analysis of case studies with emergency frame

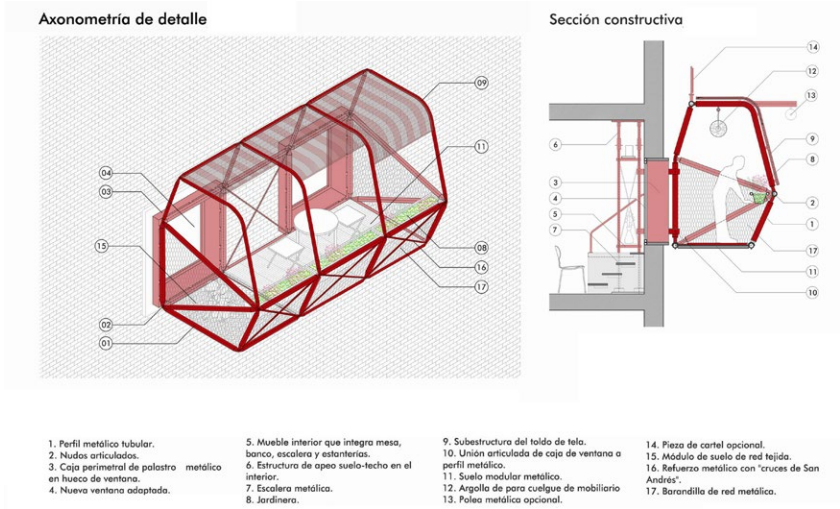
Safety solutions typologies. Case studies analysis.
Among the features that make these products so unique are their accessibility, customization, low impact on façades, multi functionality, and costs optimization. A 1-5 rating system is used to rate conditions from low to high based on the quality of the item [fig. 04]. Here we can see which factor needs to be developed more in terms of emergency escape, rescue, and refuge in the event of a crisis. Case studies have been broken down into two sections: escape solutions (emergency staircases and vertical ways) and refuge solutions.

Type 1: escape solutions (emergency staircases) When an emergency arises, one of three possible escape modes is to use a staircase either from the outside or from the inside of the building. This is in addition to a drop ladder. Today, these are generally considered to be the most common requirements for any building in order to comply with current building codes. People's ability to move rapidly is probably one of the most notable factors that contribute to their ability to escape from a dangerous situation. As a result, people with disabilities and the impaired are often faced with challenges such as these that might prove challenging to them (Hostetter and Naser, 2022).



05

05
STAYHÖME, concept for a prefabricated balcony system for dwellings, Luis Quintano, Asemas, 2020



05a

05b

Type 2: escape solutions (vertical ways) As compared to other means of escaping, the vertical means of escaping (ropes, slides, tubes, emergency lifts) provide a significantly higher degree of safety than the usual means of escaping [1]. These systems are industrially manufactured and they have to be preliminary installed on the building façade or roof with different architectural impacts and costs. This can make the evacuation of the residents of

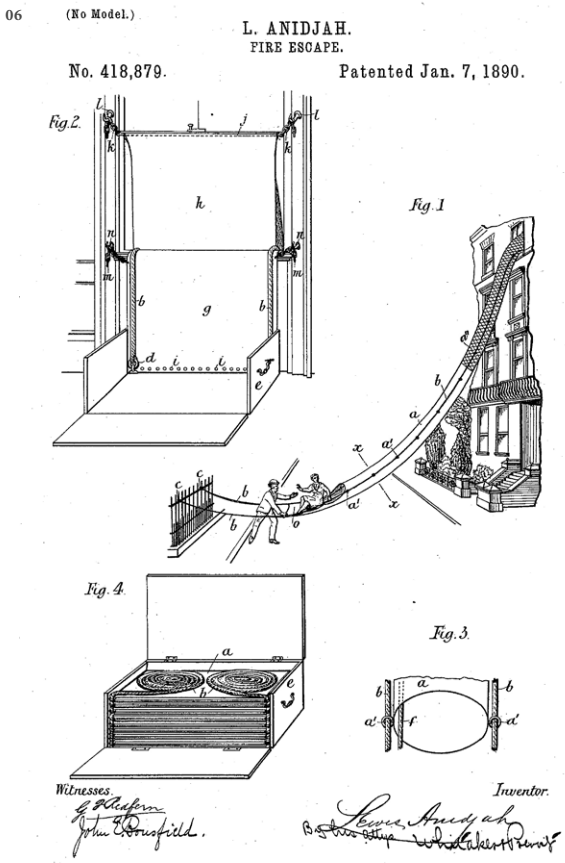
05a-05b
STAYHÖME, concept for a prefabricated balcony system for dwellings, Luis Quintano, Asemas, 2020

the structure easier and faster, but it often requires specific training and assistance for a wide range of individuals with limitations during the evacuation processes. it is also important to note that a lot of the practices we analysed is still prototypes, concept or design proposals, so these kinds of solutions are not still really suitable for spreaded applications (Mansor et al, 2019).

Type 3: refuge solutions Individuals who are disabled or have difficulty escaping without assistance are particularly at risk (Boyce, 2017). The evacuation process is not usually considered in the case of the physically challenged in many circumstances, especially when it comes to emergency situations (Ding et al, 2021). It is highly recommended that they follow the common route by foot or remain at the refuge point so they can receive assistance. Unless there is an imminent threat of death, it is normally recommended that disabled individuals stay in a room with an outside window, a telephone, and an unbreakable or fire-resistant door when considering staying in place. The Areas of Refuge are mostly the landings of stairwells (Romano, 2019). The stairwells can be blocked by wheelchairs that make it hard for people to leave. Not all floors, can serve as refuge space. Position yourself in an "area of refuge" when there is no other option available. Hence, both areas of refuge and stay-in-place have their own drawbacks, although there is plenty of room to develop these solutions. The modern building has these new standards and guidelines for construction, so what about the early modern building? Those early modern structures built long ago don't support the modern escape solution. As refuge areas are generally designed to cater to fragile individuals during emergencies, the research proposes developing them further.

Macro-phase 2. Design conceptualization

Emergency frame project. Innovative aspects In order to make better use of available exit points and increase the survivability of evacuees, the main goal of the research is to develop safe egress systems in times of emergency which will help to make more efficient use of available exit points. Inspired by the idea of area of refuge, and in relation to contemporary best practices we took into exam [2], the Emergency Frame project proposes a multifunctional, inclusive, and universal system that allows the occupant to use the space for normal activities that occur in a home also for a safety purpose. It can be used for a number of functions, such as storing plants or serving as a window shade. A frame that serves as a safety measure is attached to the exterior of the window in order



06
Case study. Lewis Anidjah's patent for a flame retardant canvas chute with a hammock at the end where the person lands is akin to the one used at the City Hall demonstration, 1890. Google Patents US 418879 A

to allow the window to be opened from either side. It is adaptable in dimensions and it is primarily designed for existing mid-rise buildings so it is suitable to increase the safety level of current dwellings. The "naked" structure is designed to have a low architectural impact on the façade: it can be customized in colours and in finishing so integrating itself as much as possible to the appearance of the existing building. According to the number of people living inside the flat, the number of frames that need to be installed on the windows should be properly calculated.

"Airbag" or "public gym"? An optimized approach to an inclusive multi functionality Regarding the functional aspect of the design proposal, it is possible to divide safety solutions in two main models: the "airbag" and the

07
White clouds, social housing block, Poggi + More, 2017. Photo Arthur Péquin

07

"public gym" approach. The first one is something that has only one specific function and that has to work in the precise instant of the emergency. Before that instant the users really do not know if it will work, if it will fit their expectation, if it will save their life. The second model represents something that has a specific ordinary and reassuring function, but that is also designed to fully fit an emergency function (a public gym can be used as a public dormitory for evacuated people). As it happens in this second example, during its ordinary phase, the frame has been designed based on the logic of a rational framework that allows for the extension of the everyday space so as to create a partially shaded semi-balcony. It consists of a number of components partially covered by a roof, creating an open-air small balcony. A window in a dwelling tends to expand the living space by a minimum of 0.7 meters and a maximum of 1.5 meters in densely populated areas. The balcony is open to the outside. If you are looking through it when closed, it looks like a normal window. Second, the frame acts as a shaded structure, which has a width of 750 mm, so that a seat or a plant can be placed within the designated area, which helps to shade the area from the sun. Restraint bars are fixed to the front elevation of the frame, which act as a barrier when keeping plants in it or when sitting inside the frame. In case of emergency, the frame is designer to be used as a safe shell, a protected area in which people can find a proper refuge. To enter the structure safely, people with disabilities need to follow the same principle applies to transitioning from a wheelchair to a bed. The frame is equipped with two shutter systems installed on either side. Since the shutters are attached to the sides of the frames, they can be raised and lowered with the screen. As they roll up and down, they are powered by motors. There is an ample amount of light that is allowed to enter through this opening. The external shutter has an emergency response sensor that sends an alert to nearby people and to emergency services when the shutter completely closes. The fire fighters may be able to get into the building more easily if there is more space and time available for them. This means that professionals saviours will have the possibility to evaluate the rescuing path: from inside the building, or from outside with the use of a fire truck and motorized ladder. It will depend to the general risk conditions of people and building and to the reachability of the person to save. Based on the overall comparative study, it was determined that the emergency frame meets all of the criteria listed in the requirements. Essentially, the emergency frame is intended to strike a balance between the needs of those seeking refuge, those seeking access, and those seeking safety egress from the area.

Technical feasibility As part of the construction process, industrial materials such as steel, iron hollow tubes, fire-resistant boards, high-performance fabrics and roller screens are used to build the emergency frame. This transfer-based design approach results in a faster production time and allows the product to be mass-produced with worldwide available materials and technologies.

Conclusions and next steps

Uncontrolled urban sprawl and extreme phenomena due to climate change are increasing vulnerability of urban settlements, today and in the near future. Presented research outcomes arise both from the critical observation of urban and demographical trends and technical limits of current solutions in terms of accessibility and inclusivity. These observations are used in the design process as in-

08

08
Emergency frame mounted to the wall

09
Assembling the components of emergency frame

puts to define a proposal that is oriented to inclusiveness, adaptability, simplicity, innovative transfer of materials and technologies from other fields and, so, industrial feasibility. In this way, starting from the minimum scale of the single dwelling, the concept proposal may contribute to a new way of designing, resilient towns on a wider

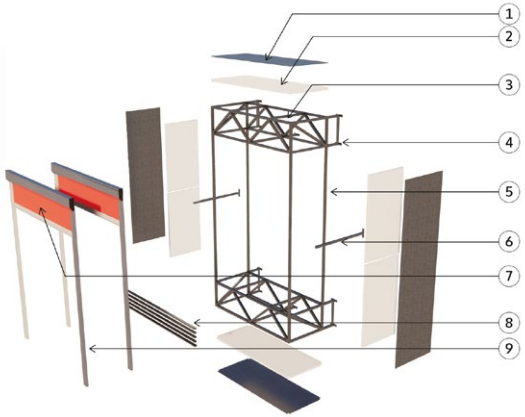


Image. 31: Assembling the components of emergency frame

1. 3mm thk Steel plate
2. 3mm thk Fire proof gypsum board
3. 430mmx750mm Metal truss
4. 10mm Metal plate fixed inside the wall
5. 30mm x 30mm Metal hollow section tube
6. Side support
7. Fire resistant screen
8. Baluster
9. Roller screen

09

10

10
Firefighters rescuing the individual from outside through emergency frame

scale of impact, by identifying new research leads to for attaining the objective of systematically integrating risks into urban environments, starting on buildings. The work is a contribution to designing urban and buildings safety systems and to creating a new form of risk management from the resilience concept that does not ignore what already exists, allowing the integration of urban development and risk reduction. Probably design cannot be able to totally reset all the possible risks in urban residential contexts, but it can contribute to understand the phenomena and to produce a social cultural swift on safety management matters and it can save lives by developing effective and inclusive solutions. The Emergency frame project is an on-going research. It is now focusing on further aspects to improve the system in terms of: engineering aspects, communication management during crisis, materials testing (mainly concerning thermal features), cost optimization, patent, prototyping and field testing.

FOOTNOTES

[1] Fire escape project (1890) by Lewis Anidjha [fig. 06], Ingstrom Escape Chutes (1988), SkySaver rescue kit (2018) can be cited as experimental prototypes for vertical escape solutions.

[2] PLUS project (2005) by Frédéric Druot and Lacaton&Vassal, White clouds (2017) by Poggi + More [fig. 07] and STAYHÖME (2020) by Luis Quintano [fig. 05] can be considered experimental and multifunctional design proposals for the transformation and refurbishing of existing residential buildings.

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