ENSURING THE
EXPERTISE TO GROW
SOUTH AFRICA

Feasibility Study for the Introduction of a New Specified Category: Glass Specialists

ENGINEERING COUNCIL OF SOUTH AFRICA
Tel: 011 607 9500 | Fax: 011 622 9295
Email: engineer@ecsa.co.za | Website: www.ecsa.co.za

ECSA

CONTENTS

EXECUTIVE SUMMARY

The feasibility study shows that the functions of a Glass Specialist require a blend of parts of many disciplines in order to successfully and cost effectively design glass. These design requirements include the correct application of glass properties; calculations of stress and deflection, the effects of interactions with support methods, solar radiation transmission, thermal insulation, sound control, failure characteristics, safety, security, colour, and reflectivity. All of these design requirements will affect the functioning and the aesthetic of the space, both internal and external, to which the glass provides more than just a simple barrier.

It is this that an educated, trained, and experienced Glass Specialist provides the necessary specialised knowledge to optimise project deliverables. The Glass Specialist has the glass knowledge to meet the legislative requirements of the installation to ensure safety – glass cuts, almost everyone has experience of this – and protection and optimisation of the internal environment and by passive design of the world's environment. A summary of the legislative requirements is included.

The feasibility study further describes how almost all parts of the National Building Regulations (NBR) have consequences for specialised glass design and how the Glass Specialist uses suitably chosen methods to design glass. The effect that glass has had on world architecture and design is also described.

A summary of the history of the Glass Specialist as nurtured by the South African Glass Institute (SAGI) and its Membership, training courses, Constitution, Code of Ethics and Continuing Professional Development programme is described in detail. SAGI has also been accepted by Engineering Council of South Africa (ECSA) as Voluntary Association (July 2020).

The feasibility report is rounded off by detailing the case for a Glass Specialist and in the final section details the tragic circumstances around the death of a matric student who fell through a glass balustrade which can only be described as having "no design".

Professional registration of Glass Specialists is concluded to be a vital part of raising the awareness of the services they provide and reducing risks associated with glass installations in projects.

To complete and assess glass designs the Glass Specialist is required to choose some or all of the following procedures: formulae described in engineering texts, national and international standards;

calculations derived from empirical methods; non-linear finite element analysis; national and international standards; onsite glass and system testing. The Glass Specialist needs the necessary education, training, and experience to choose the appropriate combination of calculation, standards, and testing to specify or assess the glass design. Failure to meet the correct design will result in glass that does not meet the NBR prescriptive regulations and will expose building owners, users and occupiers as well as passing vehicles and pedestrians to unnecessary risk of injury and death.

DEFINITIONS

SANS 10400 Part N - of the NBR, Part N Glazing.

SANS 10137 - South African National Standard referenced in SANS 10400, The installation of glazing in buildings.

Competent person (glazing) - person who is recognized by an institute, who has specialist expertise in the field of glazing, as generally having the necessary experience and training to determine glazing requirements in accordance with the provisions of this standard (SANS 10137).

Glazing- glass, plastics and organic coated glass fixed in frames in windows, doors, and roof lights, or that form doors (SANS 10400-N)

SANS 10160 Series - Basis of structural design and actions for buildings and industrial structures

Deemed to satisfy rules – a descriptive, collective term used for one method of compliance with the NBR described in SANS 10400 series of documents. Other methods include meeting the prescriptive regulations and rational design.

ABBREVIATIONS

AFTI	Australian Fenestration Training Institute
AGWA	Australian Glass & Window Association
CPD	Continuing Professional Development
CWCT	Centre for Window and Cladding Technology
ECSA	Engineering Council of South Africa
GGF	Glass and Glazing Federation
GPD	Glass Performance Days
LBNL	Lawrence Berkley National Laboratory
NBR	National Building Regulations
NGA	National Glass Association
SAGI	South African Glass Institute
SABS	South African Bureau of Standards
SANS	South African National Standards
SLS	Serviceability Limit State
TC	Technical Committee
UK	United Kingdom
ULS	Ultimate Limit State

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION AND BACKGROUND

The aim of this feasibility study is to propose the registration of Glass Specialists in their individual capacity as ECSA registered professionals and confirmed to be competent in the Glass Specialist discipline based on approved education, training, and experience.

For the ECSA Committee's appreciation this analysis of the "deemed to satisfy rules" of NBR has been completed to reference where glass is used in buildings; highlighting the importance of the correct glass design and therefore, where the expertise of a Glass Specialist will add value and regulatory compliance to a building project:

Table 1: National Building and Regulations and Building Standards

Part A - General principles and requirements	Administration forms a vital part of the regulatory requirement. It is one thing to design correctly but another to prove that the right thing has been done and in years to come that the correct person has taken responsibility for that design. Form 2 requires competent person (glazing) to design glass components where required and Form 3 allows for the sign off of the glass component of a particular structure within a building.
Part B – Structural Design	Glass as a structural component transfers load from itself to its frame and fixings to the building primary structure and then to the foundations. Glass can be typically defined as a cladding element although one which uniquely allows connection between the internal and external environments. It can also be used as a secondary structural element such as where glass fins and beams are used to support cladding elements. Also, glass is a primary structural element when directly used as a swimming pool wall, or a glass floor or stair tread. Loads and load factors from SANS 10160 are therefore used for glass design using the unique stress factors for long term loading of glass.
Part D – Public Safety	Glass is used in barriers to protect a change in level and prevent falling as both standalone structures and in windows that reach to the floor. Glass is used as pool enclosures required to protect, in particular, children, from accidental drowning. Glass design must be sympathetic to the fixings and foundations used.

Part J - Floors	Where glass is used in or as a floor it must meet the design loads described in SANS 10160 and the particular and peculiar properties of glass under static load. Provision for post failure performance, trafficability, slipping and modesty issues must be included with the particular requirements using sympathetic and appropriate supports.
Part K - Walls	Part K does not have a section for glass walls even though these are used as “curtain walls” as designed by a façade engineer and the glass as part of any wall must resist adequately and effectively the design loads from SANS 10160 as well as its own weight.
Part L - Roofs	Roofs, both accessible and inaccessible, have glass as roof lights or windows to allow natural light to penetrate, in order to illuminate atria of corporate buildings, shopping centres, factories and other large footprint buildings.
Part M - Stairways	Stairways have used glass in many types for building from residential to retail and office spaces where the glass is required to fulfil the same functions and under the design loads as for glass floors.
Part N - Glazing	The glazing regulation defines the use of glazing in buildings and defining glass designs for deemed to satisfy applications and referring to SANS 10137 for better defined and more complex and detailed applications.
Part O - Lighting and ventilation	Glazing is the only material that forms a physical barrier whilst at the same time allows in natural light. An open window or glazed door allows for natural ventilation.
Part T - Fire	Standard glass products are defined as incombustible in SANS 10400 Part T – Fire. In addition to this basic property specially designed and combined glass is used in rational fire designs to control both the spread of flame and the heat transmission of a fire.

Part XA Environmental sustainability	Glass allows heat transfer from radiative and conductive sources which are often the highest heat loads in buildings. Allied to this heat transfer is the heat build-up within the glass itself which causes, in poorly designed circumstances, the glass to crack due to thermal stress – a predictable phenomenon calculated by Glass Specialists. Correct specification of glass will result in lower energy consumption, natural light substituting artificial lighting, and transparent insulating components that can capture winter sun and reject unwanted summer sun. Correct glass specification therefore reduces energy consumption for both cooling and heating contributing to reduced greenhouse gas emissions whilst incorporating natural lighting.

Source: *SABS 2009a, 2009b, 2009c, 2010, 2011*

2 SCOPE - GLASS SPECIALIST

Glass Specialist is multidisciplinary because it does not fall completely into, a single current engineering discipline but contains elements of multiple engineering disciplines. The scope of Glass Specialist is to assess the glass requirements for a construction and to adequately generate a glass specification for the application, and to determine causes and remedies when glass fails.

But because of the uniqueness as a brittle material, the specification so generated must also describe the glass type, chemical composition, thickness, manufacturing method, inclusion of other materials to create composites, surface condition and properties, and the arrangement of the glass, its connection and support. The end result must show that the design will successfully resist the necessary structural and environmental requirements safely for the expected project longevity and with acceptable and predictable deflections meeting applicable legislative requirements without the glass tearing itself apart.

Further the specification must be sympathetically integrated into the requirement of the built environment - to create a space suitable for use. Liaison with, and therefore appreciation of, energy efficiency and the indoor environment so created, fire technology, acoustic engineering, safety, and security is within the scope of the Glass Specialist. By definition, therefore, there is also a close association of Glass Specialist to fenestration system designers. Effective collaboration increases glass performance, reduces stresses and deflections therefore creating a solution greater than the sum of its parts.

Testing forms a vital part of the scope of Glass Specialist. Because of its brittle nature only testing can show resistance to impact on the glass in a glazed system. There are tests of the material in South African National Standards but type testing is required for glazed systems which highlight weaknesses in these systems resulting in the development of a system to meet compliance to the specification or and to the NBR.

2.1 Why the Glass specialist does not fall within other Engineering Disciplines

A Glass Specialist is required to be multi-disciplinary proficient. It can best be explained using the example of a window in a building. This is the simplest and most universal of glass uses - the glass acts as a physical barrier separating the internal from external environment.

- The glass and its supports must be a barrier – stopping wind and rain from coming in. Air leaks ruin energy efficiency. Water causes corrosion, surface and eventually structural damage and fungal growth. The Glass Specialist must specify and verify suitable designs and testing and verify that the tested product is matched by that installed on site.
- Structural loads must be resisted by the glass. Distributed loads are caused by the wind. Point loads caused by a person pushing the glass. Line loads are caused by leaning against the glass. Impact loads are caused by a person falling into the glass. Seismic loads are caused by geological or mining events shaking buildings and cracking glass. Buckling loads are caused when the glass is compressed axially, when the glass is compressed from top to bottom or side to side, by planned loading. Loading may be live or static. Live loads such as generated on the glass by building movement or directly on the glass may be wind generated or caused by the movement of people or objects. These have a shorter duration and therefore require a different loading factor to static loads. Static loads are far more critical on glass than shorter duration live loading. Static loads are typified by a permanent load such as when glass holds back water or resists its own weight. The Glass Specialist must design the glass and assess glass supports, acknowledging and appreciating each load's effect on the glass – the effects of the loads are very different to structural members made of steel, concrete, or timber.

- The external window is exposed to heat from the sun. Where there is a lot of glass this can be the most important source of heat in a building affecting occupant comfort. Glass is used to control this heat. But heat will cause the glass to tear itself apart when temperature difference is too high. The Glass Specialist will design and assess the glass as suitable using their knowledge of predictive methods incorporating glass performance and arrangement, geographical factors such as climate, solar radiation and orientation, framing including frame material and colour, internal contributors such as multiple glazing, spandrel insulation material and blinds and curtains.
- Glass at its simplest is a poor insulator - it is just too thin! A window must insulate from both hot and cold weather to meet energy efficiency requirements of the NBR and to slow global carbon dioxide emissions. The Glass Specialist must choose enhanced glass types and specify framing performance. These will require multiple glazings and insulation controlling coatings that meet the performance requirement whilst optimising natural light and the calculation of the insulation value of these glass layers and coatings.
- Generation of condensation is closely allied to insulation. Condensation will corrode structural fixings, surface finishes of frames and walls and the surface of curtains generating mould spores that exacerbate asthma suffers' condition. The Glass Specialist can generate condensation predictions especially useful in condensation problem areas such as the Western Cape.
- The expected effects of high winds and airborne debris requiring post failure performance of glass and glass composites. The Glass Specialist must specify suitable glass and interlayers to meet performance and assure the client that cyclones and winter storms can be resisted.
- The failure characteristics caused by accidental breakage must assessed and causes attributed by the Glass Specialist. Glass failure and falling is an emotive subject to the building users – it is rightly perceived as very scary. Failure events result in conflict between owners and developers typically involving Glass Specialists to determine causes and remedial actions. Litigation often results and the requirement for a Glass Practitioner expert witness' testimony when falling glass causes physical injury and financial losses.
- Security threats are classified as break ins, firearm attack and explosions. A Glass Specialist is required to assess multiple projectile attack and different calibre and types of bullets, hammers, and stones. These require standardised testing. Glass Specialist can calculate to resistance to short term distributed loads resulting from explosions,

- The control of noise from outside and inside glass is the scope of an Acoustic Engineer who will typically instruct a Glass Specialist to specify a glass with the necessary noise reduction for cost effective noise control
- The colour of the transmitted light is changed by the nature of the glass in the frame. A green glass will for example dull a red surface. A Glass Specialist will be able to determine the colour shift of a particular glass for approval by an interior designer.
- The internal and external appearance is important to the architect and interior designer, both throughout the day and night. There is no one glass fits all. A Glass Specialist can present glass with different appearance properties that meet the necessary performance values to the project.
- The dynamic load resistance of accidental impacts is tested and assessed by the Glass Specialist and glass thickness and type adjusted according to the risk of failure particular for the installation.
- Legislative requirements that govern and specify safety performance of glass in buildings must be assessed and glass chosen accordingly by the Glass Specialist. By observing failed glass the Glass Specialist also provides valuable insight to future glass installations and for these to be incorporated into the next editions of the SANS standards. By serving on the relevant Glass South African Bureau of Standards (SABS) Technical committees particular to glass, Glass Specialists add to glass safety in buildings. Areas within SANS 10400 series not specific to glass require the input of Glass Specialist as glass properties are ill represented in these areas, for example, fire and energy efficiency, roofs, floors, and public safety.

3 LEGISLATIVE REQUIREMENTS

The Glass Practitioner has as alluded to, a role in the legislative requirement of the NBR. The competent person (glazing) defined in part N of SANS 10400 is a Glass Practitioner . The competent person (glazing) is determined to use SANS 10137 to design glass for applications that fall outside of SANS 10400 Part N. These include;

1. Glass in buildings that exceed the sizes and scope of tables given in the tables 1 to 10. These include larger glass sizes and in buildings higher than 10 metres
2. Glass in overhead or underfoot applications.

3. Glass used as a barrier to protect a change in level or access to a pool.
4. Glass in lift shafts
5. Glass secured with bolted or clamped fittings
6. Glass used for pool or pond windows and rim flows
7. All other glass installations not covered by SANS 10400N.

4 ECSA REGISTRATION NEW CATEGORY – RATIONALE FOR GLASS SPECIALIST

Glass Specialist is not a registered ECSA discipline/category, nor is there formal tertiary education for Glass Specialists. However, glass is ubiquitous in every South African building and roadworthy transport, used in external and internal windows, doors, partitions, and barriers, in furniture and vehicles, as transparent and translucent walls, floors and ceilings and as opaque cladding material. Glass is glaringly different from traditional construction materials as it has no crystalline structure and does not exhibit plastic deformation - as the archetypal brittle material it reaches its elastic limit and then fails. Glass Specialist is routinely inadequately detailed in construction project documentation and the design is left to the installer. Integration of the glass in the building is therefore not completed seamlessly or optimised cost effectively to provide a complete and proper solution meeting both NBR and client requirements. This must include structural integrity, serviceability limits (including deflections and other appearance criteria), post failure performance characteristics, safety, environmental performance and life of building maintenance and replacement.

SANS 10400 Part N: Glazing provides a definition of a competent person (glazing) responsible for the computation of glass thickness using SANS 10137 Glazing in Buildings. However, this definition does not extend to the definition of a competent person as described in AZ4 of the NBR: "A competent person who is registered in an appropriate category of registration in terms of the Engineering Profession Act, 2000 (Act No. 46 of 2000). The Glass Specialist will be appointed using Form 3 "Declaration by a Competent Person Appointed to Design a Component or an Element of a System" using the design loads described in SANS 10160 or the loads and conditions provided by the appointed Engineer and Architect.

The antithesis is that this unique registration category although touching on many engineering disciplines is not covered into any existing category in its entirety. In creating the competent person (glazing) definition in the deemed to satisfy rules of the NBR, TC60 (The Technical Committee responsible for the deemed to satisfy rules) determined that Glass Specialists had more unique and relevant design education and experience of building glass requirements than the majority of Registered Engineers of whichever building related discipline.

5 THE GLASS SPECIALIST – QUALIFICATION REQUIREMENTS

Minimum duration of education, training and experience for various pathways towards registration should be according to the **R-01-POL-SC:** Policy on Registration of Practitioners in Specified Categories**.**

6 GLASS SPECIALIST TRAINING AND MENTORSHIP PROGRAMME SOUTH AFRICA

There is a dearth of Glass Specialist courses in South Africa. It was only with the initiation of the SAGI that formalised training came into being in order to set a standard of Glass Specialist education. SAGI Training has been presented since 2010 developing and advancing the knowledge of members and prospective members and the greater body of building professionals such as Engineers, Architects and Architectural Technologists. The core course first developed titled "Regulations and Standards" follows the NBR, with the particular application focus of Glass Specialist, through regulatory administration requirements, deemed to satisfy rules that affect the design of the glass culminating in the Glass Specialist design rules and methods described in SANS 10137.

This first course was complimented with Advanced Courses for those who met the examination. Once the Regulations and Standards Course has been successfully completed and the two-part examination passed with a minimum required 70% in each, the Candidate Glass Specialist is appointed a mentor for further training and guided experience supported by the Advanced Courses. When the candidate has been shown, by their mentor, to meet the necessary standards for promotion (typically gauged using the CPD points system) the Candidate is presented to the Executive Committee again by their mentor, for consideration of promotion to Glass Specialist.

CPD training should be aligned to ECSA's **ECPD-01-STA:** Standard for Continuing Professional Development requirements and structure.

7 GLASS SPECIALIST EDUCATION – INTERNATIONAL

Not only is there a dearth of Glass Specialist focused training in South Africa but this is also true internationally. As a discipline there are parts of various courses which relate to the design of glass.

From Engineering Academia are core units included in Façade Engineering (a division of Structural Engineering, itself a division of Civil Engineering). One noted example is the MSc Façade Engineering (CWCT) from the University of the West of England (UK) offers a façade engineering post graduate degree course developed by the Centre for Window and Cladding Technology (CWCT) which is based at the University of Bath also in the UK. One of the core units is "Glass and Glazing" (University of the West of England, 2021).

Materials Science also adds Glass Specialist educational experience. One such example is the Centre for Glass Research which falls under the Department of Materials Science and Engineering at The University of Sheffield in the UK. Units include Research into the strength of Glass.

There are many industry bodies from around the world which offer courses in Glass Specialist in addition to their artisanal statutory and administrative training. The following represent three examples of these bodies:

1. The Glass and Glazing Design Academy a part of the National Glass Association (NGA) of the USA. The Glass and Glazing Design Academy has been established to help designers and architects "keep pace with the rapid evolution of glass in architectural design". Short courses are offered to this end ((Glass and Glazing Design Academy, 2021).
2. The Glass and Glazing Federation (GGF) of the UK publishes "The Glazing Manual" and exhaustive work detailing glass industry manufacturing standards, promoting best practice, shaping the highest technical standards. Also, a wide range of courses are offered to fit industry needs (Glass Glazing Federation, 2008).

3. The Australian Glass & Window Association (AGWA) offers access to increased expertise for all members and stakeholders in key areas, including technical support, Training, and Accreditation and Compliance AGWA through the Australian Fenestration Training Institute (AFTI) provides training that generates a career pathway for members. Glass Specialist education includes short courses on AS1288 Glass in buildings—Selection and installation covering the Australian methods of glass design analogous to SANS 10400 N and SANS 10137, including determination of glass type and thickness to withstand wind and other design loads; identify situations that require the use of a safety glass; balustrades; overhead glazing; unframed and partly framed glazing. CPD points are assigned upon successful completion of the course (Australian Glass & Window Association, 2021).

Conferences and their associated workshops of great value to the Glass Engineer. Foremost internationally is Glass Performance Days (GPD) hosted in Finland, described as "a forum dedicated to the development of the global glass industry through education" (Glass Performance Days, 2019).

In its 27th year the next event is scheduled for October 2021 and in normal times (non-COVID) happens every two years in Finland and in other locations around the world. GPD has relevance to the entire glass industry with the presentation of Masters' research projects before the glass industry. At the latest live GPD there were representatives and presenters from 24 higher education establishments from Europe, the USA and Australia (sadly none from South Africa – something to work on).

Mega glass projects by architects, designers, and engineers are show cased and workshopped in short courses to disseminate Glass Specialist design methods that result in completed and successful buildings. Current and future-oriented information on glass is provided, shared, collected, and distributed at GPD and its short courses. Short courses highlight GPD 2019 included "Improving tempered glass quality: challenges and solutions"; "An introduction to the vacuum insulated glazing technology"; "High Rise – Northern Exposure"; "The World of Glass Coatings"; "Designing facades for near zero energy buildings"; "Structural design of laminated glass including the shear coupling effect through the polymeric interlayer: a comparison of different calculation approaches".

8 GLASS SPECIALIST IN PRACTICE

8.1 Glass Specialist South Africa.

Glass Specialists design glass thickness and glass specification based on the project requirements, support conditions, loads and load duration. In construction, glazing requirements are governed by deemed to satisfy rules of SANS 10400 – N (2012), but only within the scope of 10400 N which covers the most common installations with predictable loadings. The standard covers both internal and external glazing applications where the glass is supported by a frame all round or on two opposite sides. The standard gives designs of glass thickness and type for supported all around and opposite edge support applications. It also states where safety glass is required.

All other glass applications are excluded from SANS 10400 – N. These applications are where Glass Specialist would be applied to determine glass design. Consideration is given to the type of structural element of the glazing, i.e., primary vs secondary barrier (for energy efficiency), and the effect on the building of glass failure. Loading criteria that should be considered include the following: Wind loads (SANS 10160 – 3); Live Loads (SANS 10160 – 2); Impact Loads (SANS 101060 – 2); Thermal Loads (annealed glass temperature difference) based on stress and deflection limits. The stress calculated within these glass panels must not exceed the design stress limits calculated or the deflection limits set by the specification.

8.1.1 Structural Bolted and Clamped Assembly Applications

Design must be compatible with the support and fixing details of each panel to the building structure and load requirements for example wind, line, surge, impact, and point load. Fittings and framing elements must transfer loads to the building structure and building structure loads and movements must be considered for glass and framing design. Linear fixing will react very differently to point or edge clamped glass panels. Any holes in the panels will concentrate stress in the glass panel and must be included in the design of the glass. Glass deflection limits must be included in the design. Even if stress is within the allowable limits, the deflection may be excessive. Inappropriate deflection limits may lead to scary glass and building users unease.

Figure 1: *Structural Bolted and Clamped Assembly Applications*

Post failure behaviour of the glass must be considered, and risk assessment techniques used to prevent disastrous or progressive collapse.

8.1.2 Horizontal and Inclined Glazing Applications

Figure 2: *Horizontal and Inclined Glazing Applications*

Unlike vertical glazing, designed to resist a 3 second wind load gust, inclined or horizontal glazing must also safely resist the additional stresses caused by its self-weight and accumulation of hail, snow, and storm water loads. SANS 10160 Part 2 Self-weight and imposed loads also requires loads on these inclined and horizontal surfaces. These loads are classified as being of longer duration than wind loads and have a significant effect on the required glass thickness and type. It is therefore imperative that all factors are considered before selecting a suitable glass type and thickness.

The minimum panel incline should be checked to ensure that water can run off and not add an additional longer than necessary load to glass. Where resistance to hail is required, thicker interlayers must be considered to ensure that if a panel breaks, it will remain intact in its position. Momentary or static human loading must also be considered, especially when it comes to maintenance, cleaning, and replacement of the products.

8.1.3 Balustrade and Barrier Applications

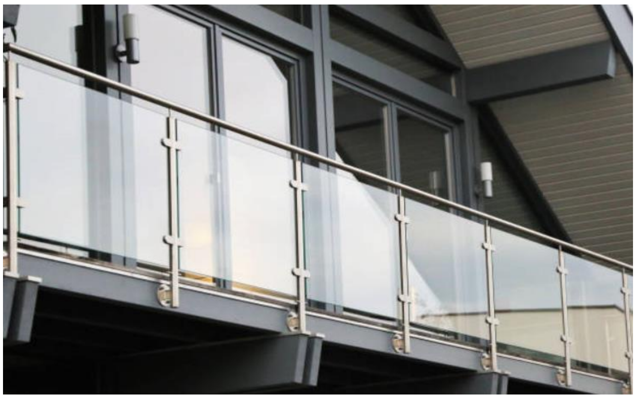

Figure 3: *Balustrade and Barrier*

Figure 4: *Balustrade and Barrier Impact resistance*

When determining the thickness and glass type for glass balustrades, barriers or floor level fenestration protecting a change in level of more than one metre, SANS 10160 Part 2 requires and impact resistance by means of a 30kg bag. Line and point load resistance must also be either tested or calculated.

8.1.4 Glass Floor and Stair Tread Applications

Figure 5: *Glass Floor*

The correct thickness of the required glass floor or stair tread will be designed using the loads described in Table 1 of SANS 10160 – 2. Once the thickness calculations are completed, considerations should be given to the deflection, as well as non-slip application. Layering factors for the behaviour of laminated glass need to be assessed. Where panels are glazed externally, thermal stress analysis must be done to reduce the risk of glass cracking.

The framework and fixing methods supporting the glass floor must consider the design load and the self-weight of the glass panel. These loads can be calculated or by load testing.

Figure 6: *Glass Floor load testing*

Figure 7: *Stair Tread*

8.1.5 Swimming Pool Viewing Panels and Rim Flow Applications

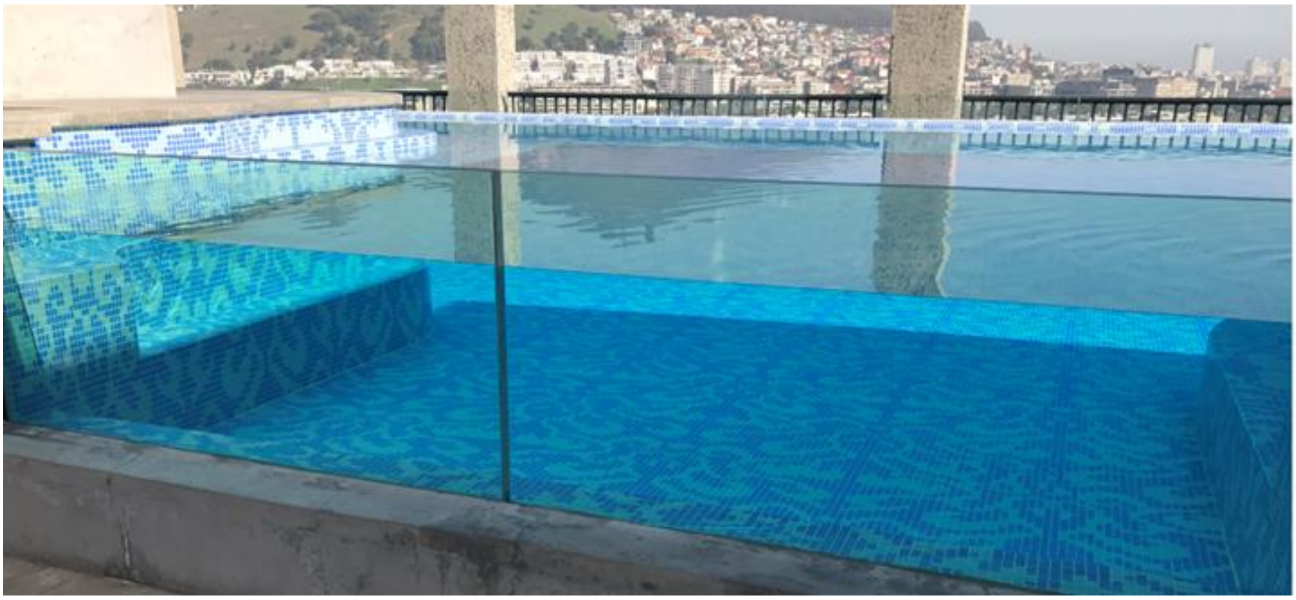

Figure 8: *Swimming Pool Viewing Panels and Rim Flow Applications*

Calculations to determine the glass thickness use long duration design stress, deflection, orientation, position, and water levels on the panels. Layering factors for the behaviour of laminated glass are also used and additional factors to ensure safety should a panel break then the water will be retained until the pool can de drained and the panel replaced. Thermal stress evaluation ensures that the glass won't crack from the differential temperature from centre to edge.

8.1.6 SANS10400–N Table Deviations

Where a wind load has been specified, the glass design can be determined using the method described in SANS 10137 which covers more design parameters than SANS 10400 N and covering more glass types, such as laminated toughened glass and sealed insulating glass units (double glazing) which are excluded in the SANS 10400 – N tables. Checks on deflections complete this design process.

8.1.7 General Testing Requirements on All Systems

To ensure that the correct design criteria have been met, physical testing can be done. This testing is split into four categories: developmental, strength, visual and verification. Developmental testing is carried out during the design process of a particular glazed system. Strength testing is the integrity of the glass structure. Visual testing allows for the aesthetics of the glass assembly. Verification testing ensures that the structure already built will meet the design criteria. These physical test results can be compared to calculated results to see whether the predication of the theoretical model has complied. Testing can be both non-destructive and destructive and is often bespoke to depending on the structure being tested.

8.1.8 Conclusions

All rational designs must take the design stress and deflection of the glass infill panel of the installation into account, as well as looking at the serviceability and redundancy of the panels. When safety glass is required, it must be marked in accordance with SANS 1263 – 1. Lastly careful consideration needs to be given to the fixing details between the glass and supporting structure, to ensure loads and boundary conditions between the various elements have been correctly incorporated.

8.2 Glass Specialist Internationally

The increased use of glass in buildings over the past few decades has pushed the glazing industry to design, fabricate and install new innovative glass structures. Glass is still primarily used as individual flat cladding panels, however, there are more applications where glass has been used as secondary and primary structural elements. Oversized float, toughening and coating lines, as well as the ability to curve glass panels more economically has given designers more flexibility to achieve unique architectural designs.

Figure 9: *Use of glass as primary structural elements Centre of German Glazing Handcrafters in Rheinbach, Germany.*

As more irregular shaped buildings are designed, the imposed loading on the cladding needs to be more accurately evaluated, to account for high localized wind pressures, possible funneling and dynamic amplification effects. Wind tunnel tests and finite element models are commonly used, as well as project specific testing, including impact testing in hurricane prone locations. Long term load durations, for regions which experience snow loads, and the effect of thermal stresses need to be carefully evaluated depending on the specific site conditions.

To achieve these new designs, Glass Engineers need to not only understand the basic material properties of glass and various loading conditions, but they also need to assess the serviceability criteria, the thermal and acoustic performance, and the interaction between the glass, the supporting frame/fixing and the main building structure.

Even though glass is an elastic material, the strength of an individual panel is determined by the interaction between the tensile strength of the glass and any micro-flaws or discontinuities in the material. This property coupled with its brittle failure mechanism leads to the overall design strength of glass being determined using statistical methods. The use of non-linear finite element packages is commonly used to model both individual glass units, made up of multiple laminates and/or insulating glass, as well as glass assemblies, consisting of multiple glass elements.

For overhead glass, or in applications where blast resistant glass is required, the post breakage performance of the glass panels needs to be carefully assessed to ensure all the design criteria are safely met.

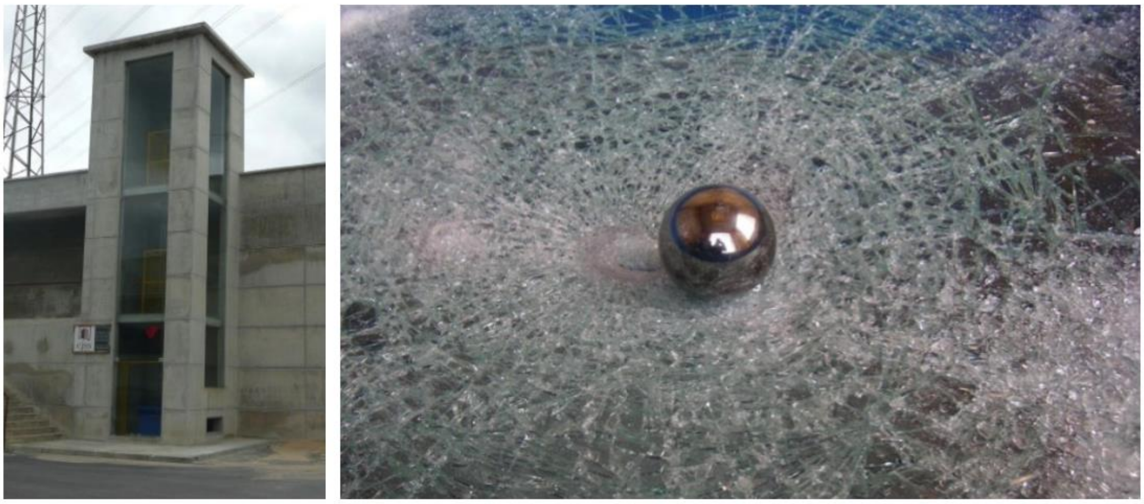

Figure 10: *Test tower for 9m high hard body drop and glass specimen broken but not perforated after hard body drop test.*

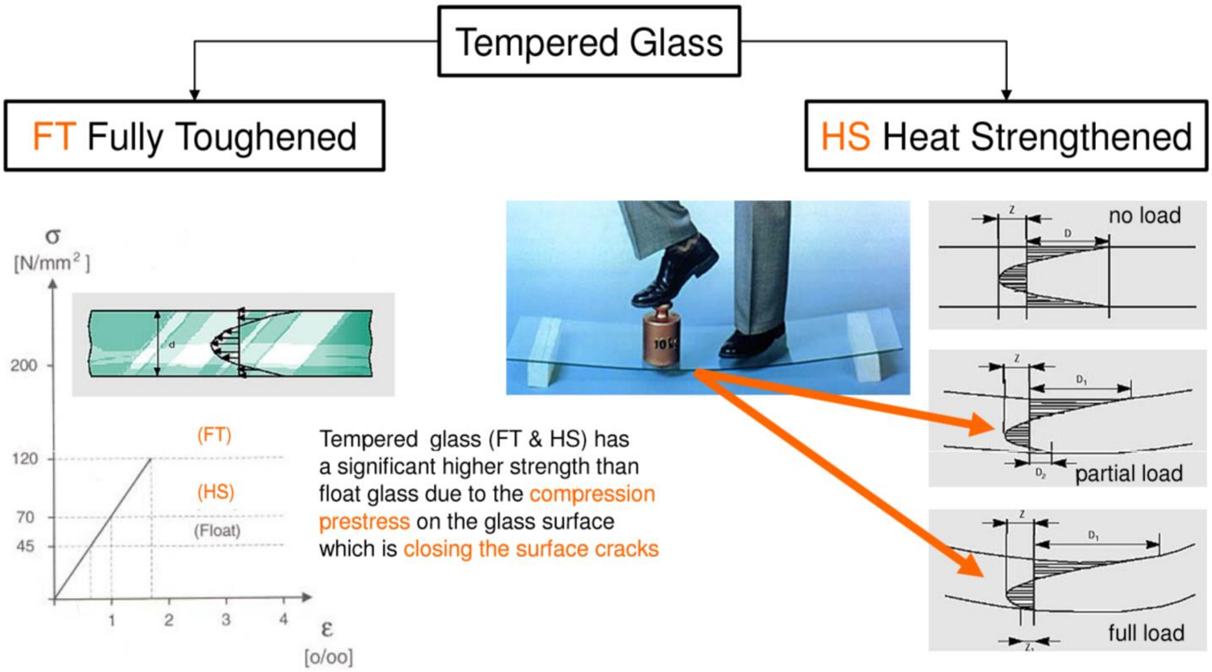

Figure 11: *Typical stress strain curve for float, heat strengthen and fully tempered glass*

In assessing the serviceability performance of individual glass elements, and the interactions between these elements with the overall building structure, Glass Engineers need to carefully assess the local and global deflections to ensure these expected movements can be accommodated. In line with the design of other structural materials, such as steel and concrete, many countries have adopted the verification of Ultimate Limit State (ULS) to fulfill the structural safety criteria and verification of the Serviceability Limit State (SLS) to fulfill the deflection criteria.

As designers continue to find new innovative ways to use glass as a building material, Glass Engineers must continue to use sound engineering principles, coupled with an understanding of new material and fabrication processes and analysis techniques, to continue to promote the safe use of glass in buildings.

9 VOLUNTARY ASSOCIATION – THE HISTORY OF THE SOUTH AFRICAN GLASS INSTITUTE

The establishment of glass manufacturing facilities in South Africa during the 1930s resulted in Pilkington technical personnel introducing glass technology and British glass standards to the South African glass industry. These aspects of Glass Specialist formed the basis for training and education largely in-house by the Pilkington Group.

The Plate Glass Group was established in the late 1800s and was a merchanting operation until the 1950s when it commenced manufacturing laminated glass for the automotive industry. In the late 1960s PG introduced laminated glass for the built environment and offered a technical advisory service to the glass industry.

Pilkington and PG merged in the early 1980s and were the dominating force to offering high-technology glass products that were backed up with a highly skilled technical team, whose Glass Specialist expertise was almost exclusively based

on British standards and Pilkington technology. Much of this technology exists today in glass related South African National Standards and Glass Specialist principles.

By 2000, the glass industry comprised several leading companies that had the capacity for offering technical advice and with the view of expanding the technical knowledge and expertise throughout the industry, the South African Glass and Glazing Association prompted the formation of an independent group of Glass Specialists that resulted in eight (8) founder members being nominated to form the South African Glass Institute in 2004.

A constitution and code of ethics was drawn up and guidance for these documents was obtained from the ECSA for which SAGI acknowledges its appreciation. The SAGI constitution is the means by which the Institution is organised, and the members are managed.

9.1 Membership and Membership seeking Registration

In 2021, membership of SAGI stands at one hundred and twelve (112) members of which ten (10) are registered with ECSA. It is expected that with immediate effect the ten (10) ECSA registered persons and that the five (5) current members defined as Competent Person (Glazing) within the deemed to satisfy rules of the National Building Regulations (SANS 10400 N) will apply for registration as Glass specialist as per ECSA policy on registration in Specified Category **R-01-POL-SC**. The balance of the SAGI members through the SAGI mentorship programme are working towards Competent Person status and will be expected in time to reach registration requirements – a potential therefore of another 90 or so members. Recruitment for SAGI membership is currently at around 15 to 20 individuals per year.

9.2 Training, Skill and Qualification Framework

9.2.1 Training

An ongoing programme of training courses is offered to members every 2 to 3 months. These courses are spread over 4 days and cover all aspects of Glass Specialist that enable attendees to complete a 3hour exam (2 parts of 1,5 hours each). A pass rate in excess of 70% for both parts entitles the Associate member to be classified as a Candidate member of SAGI. The knowledge gained in the training course enables the Candidate to offer Glass Specialist designs backed by calculations that are monitored and signed off by a nominated mentor. A mentor is a SAGI member whose membership category is that of Competent Person Glazing.

The SAGI training courses carry a South African Institute of Architects accreditation of CPD points – Refer to section 8 above "Glass Specialist training and mentorship programme south Africa"

9.2.2 Skill and Qualification Framework

Candidate members maintain a portfolio of designs and technical advice and this serves as a record of their ability to respond to Glass Specialist queries and proposals. This portfolio of activities enables the Candidate's mentor to motivate a reclassification of the Candidate member to the status of Competent Person Glazing.

The attainment of the required Continuing Professional Development (CPD) credits is crucial to being considered for being elevated to the status of Competent Person Glazing.

Candidate members and Competent Persons Glazing must complete CPD requirements in order to maintain their membership.

Candidate members must accumulate 12,5 credits in a 5-year cycle and Competent Persons Glazing must accumulate 25 credits in a 5-year cycle.

Page 18 of the SAGI Constitution outlines the qualifying criteria for a Candidate member to be considered for membership as a Competent Person Glazing.

Re: MSAGI–Competent Person (Glazing)

At the SAGI Executive Committee meeting today the submission made by the above application to be considered for CP(G), was presented, and discussed and the Executive Committee came to the following conclusions based on the criteria for eligibility to be elevated to the status of MSAGI-Competent Person (Glazing). A tick represents a positive assessment. No tick represents a negative assessment. All seven criteria must be met.

1.	Competence in offering a technical advisory service to the glass industry	☐
2.	Gainful employment in the practice of glass applications technology – time allocation	☐
3.	Qualifying CPD Points	☐
4.	Mentor motivational letter	☐
5.	Substantiating records of correspondence with regard to technical advice	☐
6.	Adequate sign-off by a mentor of technical recommendations/designs	☐
7.	Presentations and training records	☐
Pass		☐
Fail		☐

Yours Faithfully,

……………………………….. ………………………………………..

N Wright SAGI President **M Pote SAGI Vice-President**

……………………………….. ………………………………………..

C Johnston MSAGI CP(G) **N Kruger MSAGI CP(G)**

……………………………….. ……………………………………….

B Samuels MSAGI CP(G) **C Engelbrecht MSAGI CP(G)**

……………………………….. …………………………………..

A Spottiswoode MSAGI PrEng **Date**

10 BAYVIEW MANOR, MOSSEL BAY – A CASE STUDY OF TRAGEDY

The purpose of the inspection came after a fatality, directly due to the failure of a balustrade to a balcony on a top floor unit. We were requested to test the existing balustrade for legal compliance, as well as test a proposed modification to the existing balustrade.

Figure 12: *Bayview manor, Mossel Bay – modified balustrades*

The inspection and testing of the existing, as well as the modified balustrades, for compliance with the National Building Regulations, invoking SANS 10160:2 and SANS 10400:N was conducted and recorded

Original Old Balustrade Impact Test – FAIL

Figure 13: *Original old balustrade impact test*

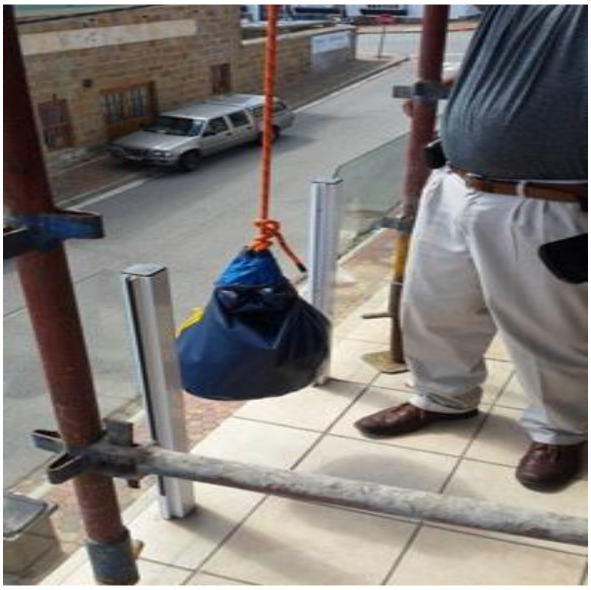

Figure 14: *Original old balustrade impact test Fail*

Modified Balustrade Impact Test – PASS

Figure 15: *Modified balustrade impact test*

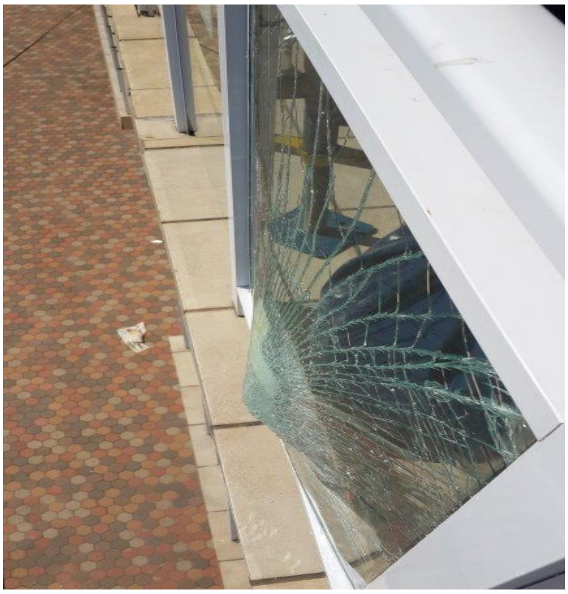

Figure 16: *Modified balustrade impact test – Pass*

11 CONCLUSION

Professional Registration of Glass Specialists as a new specified category will lead to enhancing the development of innovations in glazing technology in the built environment whilst meeting critical performance characteristics of the structures in which the glass is installed. ECSA registration will increase the profile and awareness of the Glass Specialists and the value that they will add to the projects that they work on reducing risks associated with bad or non-existent design.

12 THE CASE FOR GLASS SPECIALIST

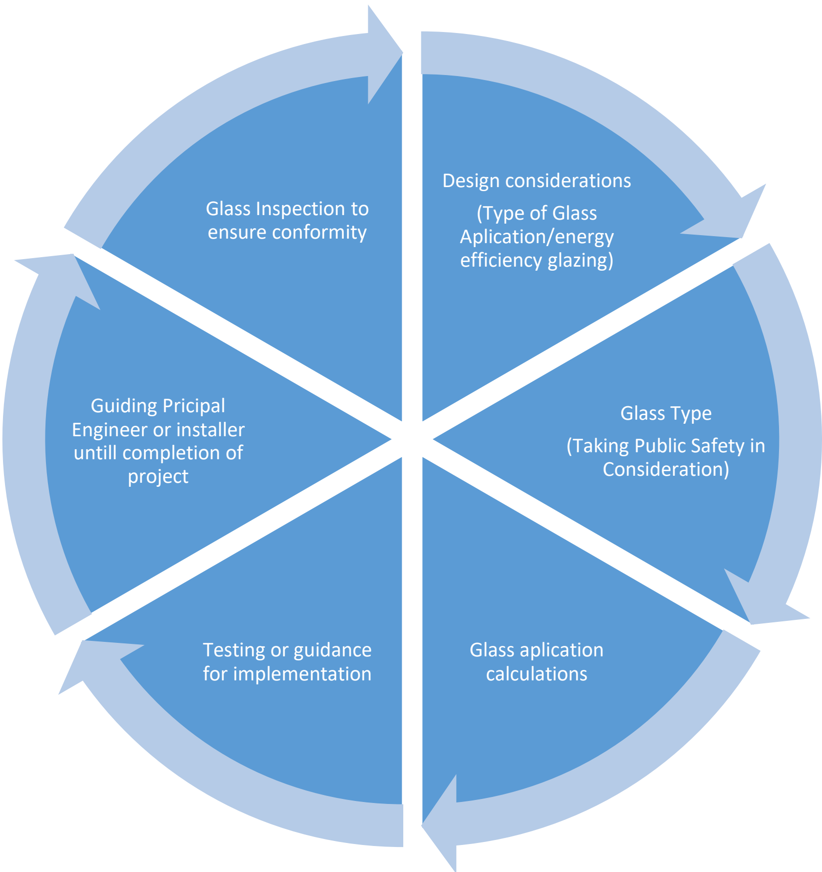

Figure 17: *The Case of Glass Specialist*

With the increase of glazing applications in buildings, it is imperative for a Glass Specialist to design and recommend glazing applications complying with national and international standards and regulations, with the main focus being on public safety.

Glass Specialist is a specialty branch of materials engineering that focuses on the design of glass, ceramics, and related composites. Glass is being used more and more as a structural element in buildings, due to the versatility and design aesthetics. Glass reacts very differently to other building materials under load bearing elements and the stress that is induced. A Glass Specialist must have an in-depth knowledge of all glass types, their capabilities and functional use in any specific application in order to incorporate in designs the correct glass that is fit for purpose.

Architects of prestigious buildings – whether in culture, politics, or business – have always used glass as a design feature. Yet today's functional buildings tend to have shapes that go much further than pure expediency, and glass is therefore used more and more frequently as a structural support element.

A Glass Specialist may design products used in construction and manufacturing. For example, buildings with glass exteriors or large glass surfaces typically require extensive input from a Glass Specialist. The engineer ensures that the materials will be assembled in a way that keeps water and air out yet are strong and durable enough to withstand normal building forces. Glass Specialists in the manufacturing field also develop products used in electronics and automotive production.

Furthermore, the load-bearing effect of the glass can be reinforced. This makes it possible to enhance not only the normal load-bearing capacity of the glass, but also its residual load-bearing capacity after potential breakage. If an appropriate and structurally efficient interlayer is used, manufacturers can now produce a laminated glass that will carry the weight of a person after breakage, despite a nearly 30% reduction in thickness.

During the last few decades developments in façade construction have led to and changed numerous products that are not directly related to façades. For example, balustrades with load-bearing properties are now becoming increasingly popular. They can be found on observation decks, in rooftop restaurants and in penthouse apartments – places where it is important to have an unobstructed view, while also offering safety.

Architects and engineers do, however, need exact specifications and thorough calculations, so that they can meet the strict requirements that are stipulated by regulations/standards to ensure safety and structural stability.

With the advancements in glass technology, such as metallic surface coatings and laboratory testing it makes it much easier to design buildings to be more energy efficient and environmentally friendly.

Apart from the aesthetics and structural design of glass, a Glass Specialist has the unique ability to specify specific glass to comply with the relevant energy legislation and to assist an energy engineer in designing a more energy efficient building with low emissions.

Lawrence Berkley National Laboratory (LBNL) in conjunction with the National Fenestration Regulation Council of America has made it possible to provide tools and measurement capabilities for local and international glass to be measured and listed to verify specific optical and spectral data in a scientific manner to ensure that it complies with the energy efficiency specification that the architect or energy engineer requires.

One main function of a Glass Specialist is to be on hand when there is a failure with a glass application scenario. Investigation will take place and a conclusion will be made regarding the reason for failure and corrective action will be recommended.

Advances in science and technology have improved both the efficiency and appearance of transparent buildings and the future generation of glass structures can be designed with more intelligence. The weight of transparent buildings can be reduced by selecting the optimal solutions in the course of an interactive design process and more options can be made available to designers by fine tuning the existing techniques of design or manufacturing. The harmful effects of static fatigue can be lessened using innovative methods of replacement and quick repair, assessing the effectiveness of both existing and innovative solutions that can be implemented to optimize designs.

REFERENCES

Australian Glass & Window Association, 2021. *Australian Glass & Window Association.* [Online] Available at: https://www.agwa.com.au/ [Accessed 15 August 2021].

British Standards Institution, 2015. *Glass in building - Thermally toughened soda lime silicate safety glass,* s.l.: British Standards Institution.

British Standards Institution, 2019. *BS EN 16612:2019 Glass in building – Determination of the lateral load resistance of glass panes by calculation,* s.l.: British Standards Institution.

Centre for Glass Research , 2021. *The University of Sheffield.* [Online] Available at: https://www.sheffield.ac.uk/materials/research/centres/centre-glass-research [Accessed 12 August 2021].

Feldmann, M., Kasper, R., Abeln, B., Cruz, P., Belis, J., Colvin, J., Ensslen, F., Eliasova, M., Galuppi, L., Gebler, A., Grenier, C., Haese, A., Hoegner, H., Kruijs, R., Langosch, K., Louter, C., Manara, G., Morgan, T., Neugebauer, J., Rajcic, V., Royer-Carfagni, G., Schneider, J., Schula, A., Siebert, G., Sulcova, Z., Wellershoff, F., Zamic, R., 2014. *Guidance for European Structural Design of Glass Components.* [Online]
Available at: https://op.europa.eu/en/publication-detail/-/publication/99288123-14cf-4406-998a-02edc22cdf84/language-en
[Accessed 10 August 2021].

Glass and Glazing Design Academy, 2021. *Continuing Education Center Architecture + Construction.* [Online] Available at: https://continuingeducation.bnpmedia.com/academies/NGA [Accessed 15 August 2021].

Glass Glazing Federation, 2008. *Glass Glazing Federation.* [Online] Available at: https://www.ggf.org.uk/publications/glazing-manual/ [Accessed 18 August 2021].

Glass Performance Days, 2019. *A forum dedicated to the development of the global glass industry through education,* s.l.: Glass Performance Days.

Novum, 2021. *Novum Structures.* [Online] Available at: https://membranes.novumstructures.com/projects/ [Accessed 9 August 2021].

O'Regan, 2014. *Structural use of glass in buildings,* London: Institution of Structural Engineers.

South African Bureau of Standards, 2009a. *SANS 10160-1: BASIS OF STRUCTURAL DESIGN AND ACTIONS FOR BUILDINGS AND INDUSTRIAL,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2009b. *SANS 10160-2: BASIS OF STRUCTURAL DESIGN AND ACTIONS FOR BUILDINGS AND INDUSTRIAL STRUCTURES — PART 2: SELF-WEIGHT AND IMPOSED LOADS,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2009c. *SANS 10160-3: Basis of structural design and actions for buildings and industrial structures Part 3: Wind actions,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2011. *SANS 10137: The installation of glazing in buildings,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2012. *SANS 10400: Code of Practice for the application of the National Building Regulations,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2013a. *SANS 1263-1: Safety and security glazing materials for buildings Part 1: Safety performance of glazing materials under human impact,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2013b. *SANS 1263-2: Safety and security glazing materials for buildings Part 2: Burglar-resistant and vandal-resistant glazing materials,* s.l.: South African Bureau of Standards.

South African Bureau of Standards, 2013c. *SANS 1263-3: Safety and security glazing materials for buildings Part 3: Bullet-resistant glazing materials,* s.l.: South African Bureau of Standards.

University of the West of England, 2022. *Centre for window and glazing technology.* [Online] Available at: https://www.cwct.co.uk/pages/msc-facade-engineering [Accessed 15 August 2021].

Young, W. C., Budynas, R. G. & Sadegh, A. M., 2012. *Roark's formulas for stress and strain,* s.l.: McGraw-Hill Education.

	Revision Date	Revision Details	Approved By
Draft A	1 April 2021	A complete report from the Research	MB Mtshali
Draft B	4 April 2021	Customization to ECSA format and	MB Mtshali
Rev. 0	12 April 2022	Consideration and approval	RPSC
Rev. 0	23 June 2022	Consideration and approval	Council

Feasibility Study for the Introduction of a New Specified Category: Glass Specialists

Revision 0, dated 12 April 2022, consisting of 41 pages, was reviewed for adequacy by the Business Unit Manager and approved by the Acting Executive: Research, Policy and Standards **(RPS)**.

2022/07/19

Business Unit Manager

Date

2022/07/20

Acting Executive: RPS

Date

This definitive version of this research report is available on our website.