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## The Apple Stores: "a progression of structural strength in stair/balustrade ensembles made of laminated glass."



James O'Callaghan

**Structural engineer James O'Callaghan has made his name by way of a progression of excellence in Apple Store laminated glass stairway and balustrades ensembles worldwide. Formerly of London and New York-based structural engineering firm, Dewhurst Macfarlane PC., O'Callaghan set up his own London-based firm [Eckersley O'Callaghan Structural Design Ltd.](#), with a former colleague, Brian Eckersley in March 2004.**

For each staircase/balustrade ensemble, O'Callaghan worked with Dr Steven J. Bennison and his team at DuPont Glass Laminating Solutions' Central Research & Development in Wilmington (USA). This research team was invited to assist the architects' and engineers' state-of-the-art use of DuPont™ SentryGlas® Plus structural interlayer for the stair treads and DuPont™ Butacite® PVB interlayer for the balustrades in all new Apple Stores to date - and more coming.

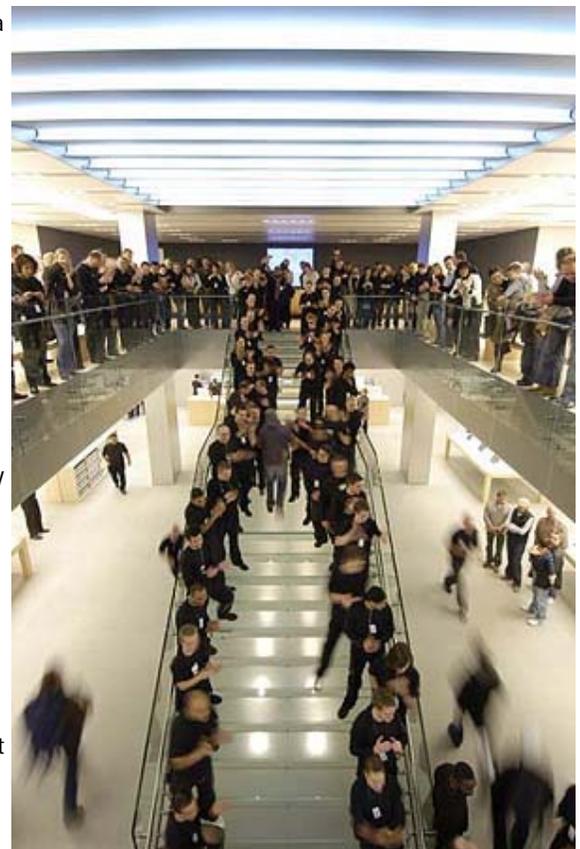
The architects for the Apple Stores worldwide, Bohlin Cywinski Jackson of Berkeley (CA) USA, worked with a 'cast of thousands' of laminated glass specialists, including Seele GmbH of Gestorfen (Germany), the glazing contractor for every staircase undertaken to date; Depp Glass Inc. of Long Island, New York City (the laminator for the stair treads containing SentryGlas® Plus structural interlayer); BGT Bischoff Glasstechnik GmbH of Bretten, Germany, the laminator for the balustrades and skylights of the stores in SoHo and Regent Street, Tripramid Structures Inc. of Westford, MA (USA) who worked on the stainless steel fittings. For the Regent Street (London) store, Carpenter-Lowings of London worked on the aesthetically striking glass ceiling, which features illuminated, laminated glass panels. More recently, credit goes to laminator Isoclima of Padova, Italy which supplied the curved, laminated chemically tempered glass balustrades for each of the Japanese stores.

Laminated Glass News: Please tell us about the Regent Street (London) Store.

**James O'Callaghan:** The 10 m- (33 ft)-long, 6 m-(20 ft)-high staircase and balustrade assembly, which is enhanced by a specially-designed, illuminated glass ceiling and bridge by Carpenter-Lowings in the Regent Street Apple Store in London follow on from the original SoHo store except that the stair treads are wider at 2.4 m (7.8 ft) instead of 2.1 m (6.9 ft).

Working with Depp Glass for the laminated glass stair treads containing SentryGlas® Plus structural interlayer we knew that we were really pushing the envelope in terms of testing the rigidity and span capabilities of DuPont's structural interlayer here - but the design team and the interlayer rose to the challenge! The staircase is supported by laminated toughened glass walls or balustrades containing Butacite® PVB supplied again by Bischoff. Like the SoHo store, these balustrades act as the primary load-bearing structure, supporting the annealed laminated glass stair treads, containing DuPont's structural interlayer for rigidity and stiffness.

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Regent Street Apple Store grand opening in London  
(more photos at end of article)

LGN: Please tell us how the new Japanese Apple Store staircase/balustrade ensembles were achieved.

JOC: The balustrades of the stairway in the Apple Store in Osaka, which takes the form of a helix, are formed with curved, chemically toughened glass panels, spliced together with stainless steel fittings. We selected chemically-toughened laminated glass because it is about three times stronger than standard, heat-toughened laminated glass in the construction used by supplier Isoclima (three layers of 10 mm (0.4 in) glass and two 1.52 mm- (60mil)-thick PVB interlayers).

The 1.8 m- (6 ft)- wide treads, meanwhile, are made of layers of a four-ply annealed glass, laminated together with SentryGlas® Plus, with a special, crystal-like, polished edge. The overall effect of these wide treads is that of a 'grand curved staircase', an architectural fixture that could easily be used for special product launches or other special marketing or social events.

Provision for seismic loading was essential for the staircases and balustrades in the Japanese Apple Stores. Seismic loads are effectively resisted in the Osaka staircase/balustrade ensemble by the combination of the laminated glass stiffness inherent in the helix design of the laminated glass handrail or balustrade containing PVB and the stainless steel helical handrail.

There was actually a significant earthquake in Osaka, just two weeks after this stairway was installed. I flew out to inspect it, and the laminated glass stair and balustrade were both in perfect condition.

LGN: Please tell us about the laminated glass stairway and balustrade at the Apple Store in Nagoya, Japan.

JOC: This stairway and balustrade ensemble is perhaps the most innovative that I have worked on. The glass walls or balustrades to the stairs in Nagoya structure demonstrate an engineering step-change compared with the SoHo staircase. In SoHo, the laminated glass walls came down to meet the floor. In Nagoya, the staircase itself is constructed as a spanning beam so that there is no need for the laminated glass walls to touch the floor; they surround and protect the stairway with a constant depth that is much more demanding, structurally, and very elegant!

LGN: Please tell us about the Apple Store in Shibuya, Tokyo.

JOC: The fourth Apple Store in Japan in the famous downtown bustling district of Shibuya, Tokyo, represented new structural challenges. The glass stair evolved from the helical form developed for the Osaka store. The handrail or balustrade laminated glass panels are joined with stainless steel fittings, creating a single, structurally continuous ribbon that spans from the ground floor up to the first floor as a vertically-spanning, curved glass beam. This laminated glass curved glass beam supports the glass treads, which are laminated using SentryGlas® Plus, and are used to laterally tie the glass ribbon back to a surrounding metal frame encased in steel panels.

LGN: Are there any major changes that you believe the laminated glass industry should be making as a result of your learnings on the Apple Stores stair/balustrade commercializations?

JOC: When we take on the challenges of developing complex glass structures, we need the industry to share the enthusiasm we have for developing new ideas. This is not often the case and it would be more encouraging - and result in industry progression - if a lot of the laminators were prepared to invest a little more in the development of some of the ideas we propose! It has to be a team effort for there to be success - from the client level right the way through every step to the final installation team. Clearly, the laminators are a key factor to this team success.

LGN: Lastly, how do you think architects can apply the learning from all your work with the Apple Store staircase/balustrade ensembles when it comes to other laminated glass applications like façades, structural fins and floors?

JOC: With the development of these glass structures we have always had to consider the capacity of the laminated glass to withstand load, the redundancy mechanism and the manner in which all the glass elements are connected. This process is no different should the structure be a stair, a fin or a floor, there are just different types of loads and different redundancy considerations. This being the case, architects should not feel initially restrained when considering the use of laminated glass! It is the job of structural engineers to harness architects' inspiration in the form of safe and achievable structures. With this approach in mind, I believe we have many avenues open to us for the use of glass in varying structural forms and these should not be limited to floors, balustrades and façades.

Clearly, the enhanced strength of SentryGlas® Plus interlayer has resulted in the ability of the glass floors and treads we have used to span the distances they have, to resist the loads they do, and to provide a very high level of redundancy in failure. This would have not been possible in the same manner with PVB, and for that reason the application of SentryGlas® Plus should always be considered where the laminated glass element is structural, or when failure modes are an important design or engineering consideration.

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Man leans over balustrade of laminated safety glass. Apple Store staircase and balustrade, Regent Street, London (UK), with illuminated laminated glass roof by Carpenter-Lowings (2004).

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Apple Store staircase and balustrade, Osaka, Japan (2004)

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Apple Store staircase and balustrade, Nagoya, Japan (completion: January 2005)

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Apple Store staircase and balustrade, Shibuya, Japan (completion: August 2005)

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