

Playing to strength: duplex gains market share in construction and transport



Urbanization is sweeping the world, thanks largely to rapid growth in Asia and the Middle East. This growth is not only economic, but affects also the size and complexity of the world's cities. Large conurbations require buildings, airports, water treatment facilities, water management, flood protection, canals, roads, railways, bridges and transport. In each of these sectors demand for duplex is soaring.

By James Chater

Traditional markets

Duplex stainless steel continues to shine in its traditional sectors of oil and gas, petrochemicals, pulp and paper and desalination/marine applications. These areas have seen demand that is steady though not always spectacular. Oil and gas was badly hit by the 2008

financial crisis and is only now returning to modest growth. Nevertheless, there seems to be no lack of demand for duplex stainless steel products. Vallourec recently started up its umbilicals factory and has successfully assembled Vallourec Umbilicals welded super-duplex tubes at Total's Edradour

and Glenlivet gas condensate fields. Sandvik just boosted its presence in offshore Egypt with a record number of contracts, including some for its super-duplex umbilical tubing, and will also provide the tubing for the Leviathan gas project in the eastern Mediterranean. China's TISCO has strengthened its



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position in the North Sea by receiving Norsok M-650 approval for its duplex stainless steel. With offshore operators planning to extract at greater depths, with temperatures and pressures that exceed current capacities, there is ample scope for producers to come up with even stronger super-duplex and hyper-duplex grades.

The offshore industry is also ordering valves made of duplex or super duplex. In 2017 PJ Valves PJV delivered forged cast gate globe and check valves in super duplex and super alloys for Maersk's Culzean field in the North Sea. Ahmedabad-based Oswal Industries Limited is supplying super-duplex ball and check valves to Kuwait Oil Company's Lower Fars project.

What's new in duplex?

- 3D manufacturing was first developed in austenitic and nickel- or titanium-bearing grades, but is now spreading to duplex. Duplex and super-duplex grades are being used to 3D-manufacture flanges.
- CAD (computer-assisted design) has been applied to products made of 2205 duplex. A weakly ferromagnetic stent was made using CAD, and its design was further refined using finite element analysis (FEA).
- SeAH Changwon Integrated Special Steel (SeAH CSS) has commissioned a tube extrusion press line in Changwon, South Korea. It has an annual capacity of 35,000 tons of tubes in diameters between two and ten inches in duplex and super-duplex alloys as well as austenitic steels and special steels.



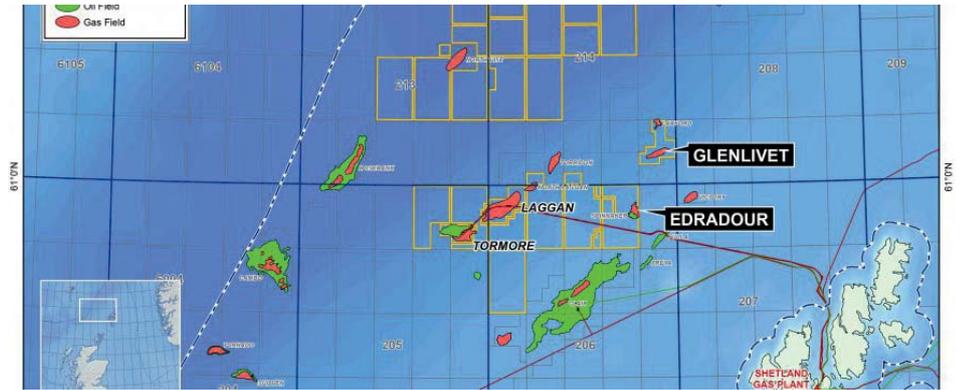
Manufacture of umbilicals at the Vallourec Umbilicals plant in Venarey-les-Laumes, France. Photo: Stephan Caso.

[DUPLEX]

The petrochemical industry was given a major boost earlier this year with the news that Kuwait will invest USD 8 billion in overseas projects over five years. In the USA, several plants, mostly fuelled by shale gas, are coming on line this year, while it is widely believed that a second wave of investments is imminent, which would come on line in 2020 or after. Earlier this year Outokumpu delivered 500 tons of Forta DX 2205 duplex stainless steel for the second-phase development of Jiaying Petrochemical's PTA plant in Zhejiang province, China.

Pulp and paper is an industry that is seeing steady growth. An ever wider array of duplex stainless grades is being applied. This is partly due to the discovery that lean grades (LDX 2101® and 2304) are preferable to standard grades such as 2205 in digesters because molybdenum has a detrimental impact in hot alkaline solutions. Accordingly, Outokumpu has won several orders for lean duplex grades to pulp and paper mills in recent years. In 2016 Outokumpu delivered 140 tonnes of Forta LDX 2101 and Forta DX 2205 plates to a bioproduct mill in central Finland.

Desalination and (waste)water treatment is a rapidly growing industry that will consume large amounts of duplex. Last year NSSC delivered about 7,500 tonnes of its 2120 lean duplex plates to a Qatari plant being built by Hitachi Zosen. Valbruna delivered a combination of duplex and austenitic grades for the Bulimba Trunk Sewer upgrade in Australia. In desalination too, duplex valves are in demand. When Singapore planned its fifth desalination plant it specified large butterfly valves in duplex from Parcol. In wastewater treatment, evaporation is being increasingly explored as a substitute



The Glenlivet and Edradour projects in the North sea.

for liquid disposal. Veolia recently designed a two-stage evaporation process for a chemical company, with both evaporators made of SAF 2507 super-duplex, leading to a huge reduction in treatment costs.

Construction

A striking trend is the increased use of duplex in construction and transport, two sectors that are especially associated with accelerating urbanization in high-growth economies, especially in Asia and the Middle East. One of the most megaproject-obsessed countries is Kuwait, which has ambitious plans to diversify its economy away from oil. The kingdom is setting aside USD 11.3 billion for 30 infrastructure projects, including a causeway, roads, bridges, a metro, a wastewater treatment plant, a refinery, an airport expansion and a port. Kuwait is closely followed by a number of other countries, notably Dubai (airport, canal, museum, waterfront complex, amusement park, shopping mall, skyscraper) and the rest of the UAE (simulated Mars colony in the Emirati desert, the start of a project to build a colony on Mars); India (road projects, the country's longest sea bridge,

railways, waterways, a port, various industrial projects); China (the gigantic South-to-North Water Transfer Project, the world's largest airport terminal, the Hong Kong – Zhuhai – Macao Bridge); and Saudi Arabia (mosques – including the controversial redevelopment of the Holy Mosque in Mecca – entertainment, housing, the Jubail II industrial complex).

Bridges

Duplex is in especially high demand for bridges in coastal areas. Here duplex's unique combination of corrosion resistance and structural strength comes into its own. Corrosion can come not only from the saline atmosphere of coastal areas but also from de-icing salts used on roads. Other essential criteria include duration (120 years is standard), reduced life-cycle and maintenance costs and resistance to severe storms. Several bridges have been constructed in duplex (or other stainless grades), the first being the Suransuns Bridge in Switzerland (1999). At first, type 1.4462 (2205) was used exclusively, but later the lean grades 1.4362 (2304) and 1.4162 (LDX 2101®) were introduced (1). Notable examples under construction include the Sheikh Jaber al-Ahmad



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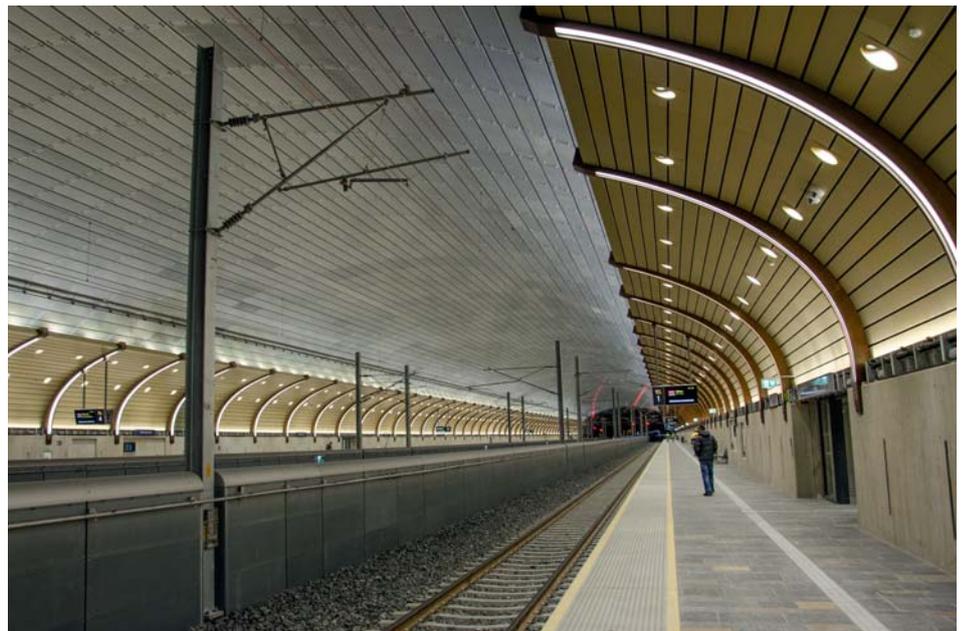
Al-Sabah causeway in Kuwait, the new Champlain Bridge near Montreal, Canada, and the ambitious Hong Kong – Zhuhai – Macau Bridge in China, the longest sea bridge in the world (table).

Other infrastructure

The world’s megacities require public transport. Whether it is roads, railways, canals, dams or ports, all are promising areas for duplex. India is overhauling its road network, London is building its Crossrail metro line and California is building a fast train link between Los Angeles and San Francisco. In Australia’s longest road tunnel, in a hot and corrosive environment, duplex type 1.4462 (2205) was applied in the tunnel lining supports of the smoke and heat extraction system. When the London Underground renewed Old Street Station, the steel linings that had been corroded by acid were replaced by super duplex. Duplex hollow bar in type 2205 from Sandvik was used to support the structure of the recently completed Holmestrand Station, built on a mountain in Norway. Water management is an increasingly necessary activity in our fragile environment. The Södertälje lock in the Södertälje Canal, Sweden, is being refurbished with an extension and widening of the lock chambers, the construction of two new lock heads and lock gates plus a new bascule bridge. The lock gates, made to a special design, will be a segment gate made of duplex steel. Arcelor-Mittal won an award for the duplex materials it supplied to the tidal sluice gates at Mont Saint-Michel off the north coast of France. Another example of maritime use is the corrugated duplex bar supplied by Acerinox to the port of Monaco. The material provided by Acerinox will be used to reinforce the protective barrier against the sea.



Model of Champlain Bridge near Montreal, Quebec, Canada.



The new Holmestrand train station in Norway. Photo: Peter Fiskerstrand.

Recent bridge constructions using duplex stainless steel.

Dates, stage	Description	Application, grade, producer
Commissioned 2009.	Stonecutters Bridge, Hong Kong.	High towers are composite sections with an outer duplex stainless steel skin and a reinforced concrete core; tubes and plates, 1.4462 (2205), Outokumpu.
Construction started 2005; opened in 2010.	Helix Bridge, Marina Bay, Singapore, pedestrian bridge.	2 helixes made of stainless steel pipes, 1.4462 (2205), Outokumpu.
Delivered 2016-7; in service in 2018.	Sheikh Jaber al-Ahmad Al-Sabah, Kuwait.	Rebar, Forta DX 2304, Outokumpu.
Construction started 2015; completion scheduled for 2018.	New Champlain Bridge spanning the Saint Lawrence River in Montreal, Canada.	Rebar, 2304, including Rolltec® rebar couplers and anchors from Dextra.
Under construction.	Hong Kong – Zhuhai – Macau Bridge, China; includes link roads, tunnels, boundary crossing facilities on an artificial island.	Rebar in splash zones, 1.4362 (2304), Roldan (Acerinox group); bridge bearing platform, tower foundation and pier shaft, rebar, 2304, TISCO.

Disaster protection



View from the East Cliff of Cromer, as seen in a 19th-century postcard.

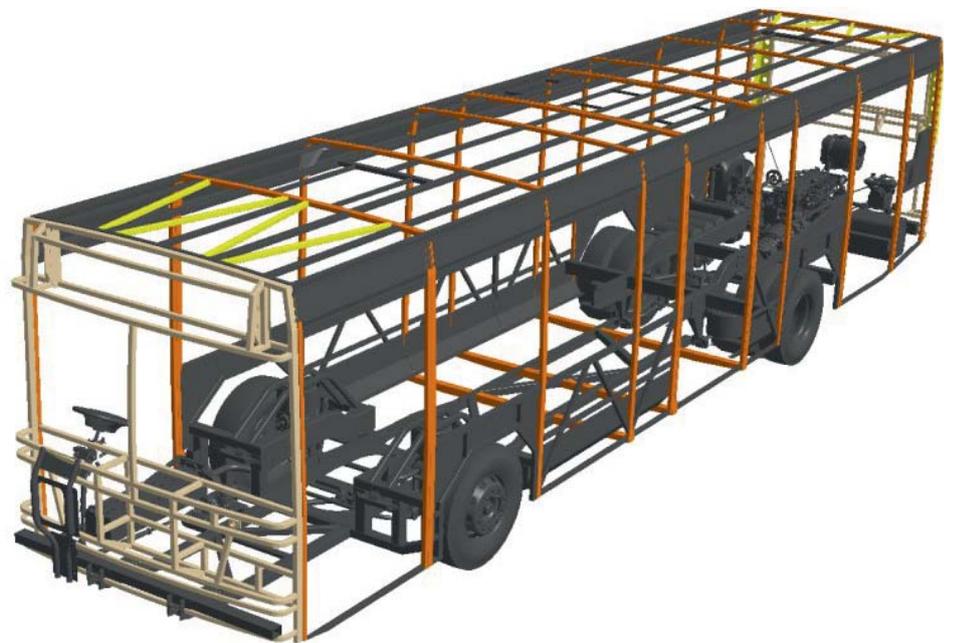
Global warming is causing sea levels to rise, making storm damage more frequent. Here is where duplex's unique combination of strength and corrosion resistance (specifically, resistance to salt water corrosion) comes into its own. The cliffs and sea front at Cromer, Norfolk, UK, are especially beautiful, and when a coastal protection scheme was implemented, Forta DX 2304 duplex stainless steel rebar was used to reinforce the sea defences.

A major cause of flooding is earthquakes, the Japanese tsunami of 2011 being a prime example. Since then IHI has installed floodgates with duplex supplied by NSSC. Duplex can also play a role in defending buildings from seismic damage. Type 2205 was one of a number of stainless grades used in an experiment carried out by MCEER on the fatigue behaviour of stainless rebar for earthquake engineering applications. We can expect to see duplex applied more often in tall buildings in earthquake-prone cities like Tokyo and Manila.

Transport

Ships and vehicles are also increasingly turning to duplex grades. In shipping, chemical tankers have been using duplex to line their cargo holds for some time. Recently, however, duplex has been applied on smaller boats. A yacht by SSY was built entirely of Forta SDX 2507 to achieve a considerable weight saving. The futuristic Tetra, a yacht with a pyramid-shaped body that would lift itself above the water at high speeds will, if built, have a hull made from duplex stainless steel.

The design of trains, trams and buses is being transformed as manufacturers turn to stainless steel, including duplex, to achieve lighter bodies and fuel savings. In 2013 the Vossloh Group replaced ferritic on its trams with LDX 2101® to achieve great corrosion resistance and strength. In 2017, in response to tighter regulations, Stala launched two grades, one ferritic, the other duplex, for use in lighter-weight bus bodies. The lean duplex



In 2014 Ashok Leyland proposed a design for a bus made of ultra-light stainless steels.

grade STALA630D (EN 1.4062) has a yield strength of up to 630 MPa, with excellent elongation and energy absorption properties. In 2014 India's Ashok Leyland proposed a design for a bus made of various ultra-light grades: 1.4003, LDX 2304, LDX 2305 and SS Nitronic 60.

Finally, duplex is being used in the ultimate load-bearing application, crane booms. When Montanstahl designed a crane for the tender of a luxury yacht, it rejected 316L in favour of a lean duplex grade. The result was a smaller beam, allowing reduction of the section size and of material thickness. In Florida, Stainless Structurals chose type 2205 for its davits, a type of crane used in marine environments.

Conclusion

The advent of a number of new duplex grades, especially lean ones, is going hand in hand with the trend towards urbanization in the world's fastest-growing economic regions. As architects and manufacturers learn about the advantages of these grades – life cycle and maintenance cost savings, strength and corrosion resistance – they are increasingly willing to pay more up front in order to achieve long-term savings. Duplex is literally building the future.

References

- (1) "Sustainable Duplex Stainless Steel Bridges" (ISSF brochure), downloadable at www.worldstainless.org.



The Tetra yacht will have a hull made of duplex stainless steel