Aluminium alloys and solutions used for bridge constructions. Russian experience

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INSTITUTE OF LIGHT MATERIALS AND TECHNOLOGIES (LMTI) – R&D center of RUSAL for the development and implementation of new products

Strategic goals

- Development of the new high VAP, technologies of their production and application (alloys, composite materials, ceramic and reinforcement materials)
- Scientific and technological support of production and implementation of the new products and solutions into industry
- Forming of the industrial scientific cluster of consumers and developers for the expanding aluminium products to the new markets

LMTI Staff

42 employees 15 of whom has PhD degree

Location: Russia, Moscow, Leninsky av. 6-21

LMTI competencies

Department of casting alloys

- Advanced alloys
- Casting technologies
- Combined technologies for the production

Department of additive technologies

- Materials for 3D printing
- Technologies for printing parts
- Production of powders

Department of wrought alloys and composite materials

- Alloys and MMCs
- Extrusion, drawing, rolling, forging processes

Department of chemical technologies

- New non metallic products
- Alloying and reinforcement materials
- Technologies for fluorides and rare-earth materials1

More than 12 current R&D projects

More than 20 partners within Russian and foreign universities and companies

More than 20 в types of new products under development

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SOME HISTORICAL BACKGROUND

30 September 1969

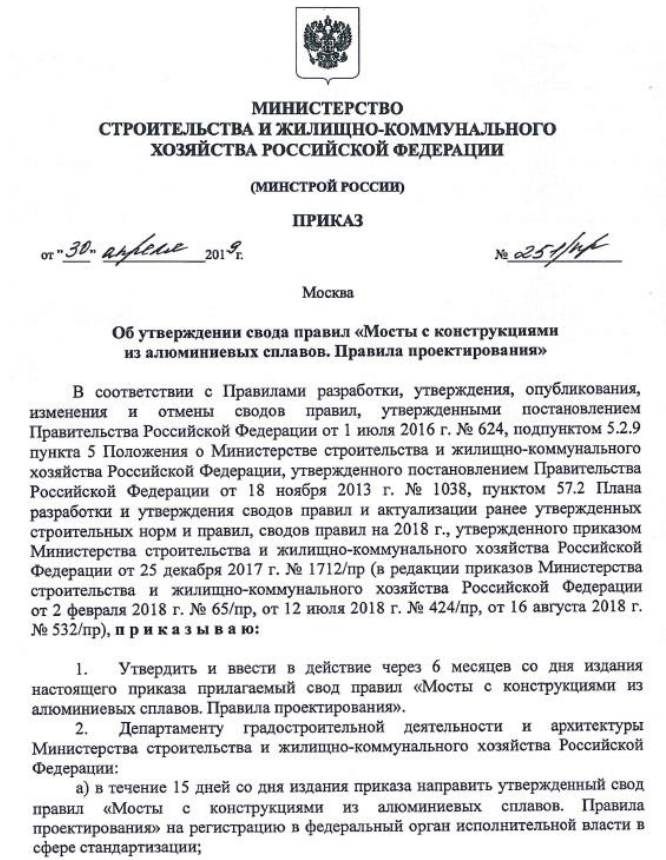
first full aluminium bridge in Russia was opened in St. Petersburg

(Kolomenskii bridge)

- Fully welded aluminium structure using 270 mm tube as an arc support;
- Weight is 8 108 kg;
- Material – low alloyed aluminium lead to perfect corrosion resistance;
- Bridge is still under service (recent investigations show satisfactory conditions);

CURRENT REGULATION IN THE FIELD OF BRIDGE DESIGN

DESIGH RULES **СП443.1325800.2019** «Bridges with aluminium constructions. Design regulations»



МИНИСТЕРСТВО
СТРОИТЕЛЬСТВА И ЖИЛИЩНО-КОММУНАЛЬНОГО
ХОЗЯЙСТВА РОССИЙСКОЙ ФЕДЕРАЦИИ

(МИНСТРОЙ РОССИИ)

ПРИКАЗ

от "30" апреля 2019 г. № 254/пр

Москва

Об утверждении свода правил «Мосты с конструкциями из алюминиевых сплавов. Правила проектирования»

В соответствии с Правилами разработки, утверждения, опубликования, изменения и отмены сводов правил, утвержденными постановлением Правительства Российской Федерации от 1 июля 2016 г. № 624, подпунктом 5.2.9 пункта 5 Положения о Министерстве строительства и жилищно-коммунального хозяйства Российской Федерации, утвержденного постановлением Правительства Российской Федерации от 18 ноября 2013 г. № 1038, пунктом 57.2 Плана разработки и утверждения сводов правил и актуализации ранее утвержденных строительных норм и правил, сводов правил на 2018 г., утвержденного приказом Министерства строительства и жилищно-коммунального хозяйства Российской Федерации от 25 декабря 2017 г. № 1712/пр (в редакции приказов Министерства строительства и жилищно-коммунального хозяйства Российской Федерации от 2 февраля 2018 г. № 65/пр, от 12 июля 2018 г. № 424/пр, от 16 августа 2018 г. № 532/пр), **п р и к а з ы в а ю:**

1. Утвердить и ввести в действие через 6 месяцев со дня издания настоящего приказа прилагаемый свод правил «Мосты с конструкциями из алюминиевых сплавов. Правила проектирования».

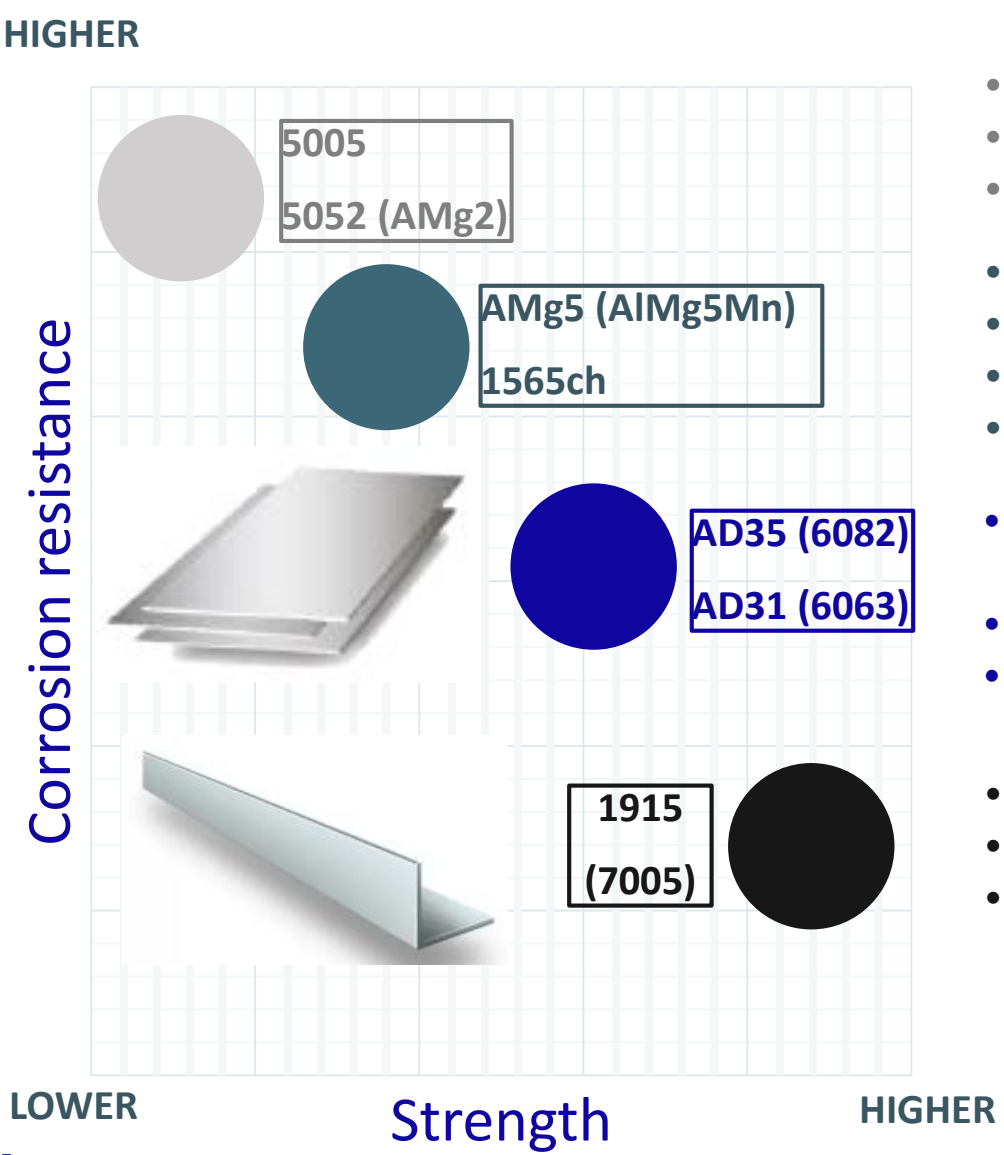
2. Департаменту градостроительной деятельности и архитектуры Министерства строительства и жилищно-коммунального хозяйства Российской Федерации:

а) в течение 15 дней со дня издания приказа направить утвержденный свод правил «Мосты с конструкциями из алюминиевых сплавов. Правила проектирования» на регистрацию в федеральный орган исполнительной власти в сфере стандартизации;

Activities for the expansion of aluminium application

- Investigations of aluminium alloys including novel ones in the form of different shapes;
- Creation of Russian National standard (GOST) for the Semi-finished products of aluminium alloys for bridges. General requirements;
- Fireproof tests of aluminium structures for the creation of concept of road bridges;
- Revision of Set of rules for the bridge structures in order to widen the application of aluminium;

CURRENT ALLOY SOLUTIONS FOR THE BRIDGES



- Superior corrosion
- Non-heat treatable
- Only for decorative use

- Good corrosion
- Perfect weldability
- Poor extrudability
- Used mostly in plates

- Balance of strength and corrosion resistance
- Used for extrusion mainly
- For structure use

- Best strength
- Stress corrosion sensitive
- Weldable but used only in bolted structures

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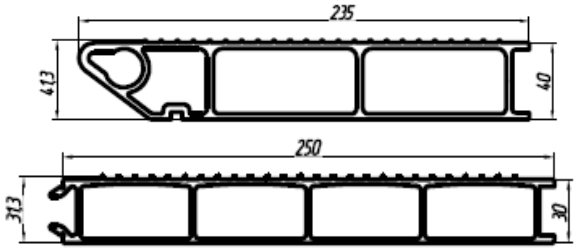
INNOVATIVE TECHNOLOGIES FOR JOINING

Friction stir welding have been successfully tested and is implementing for the creation of large orthotropic panels suitable for the flooring



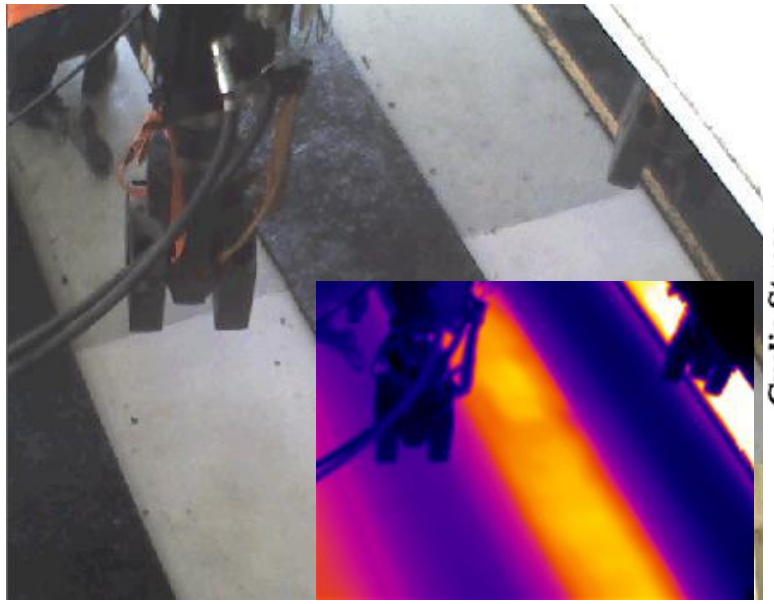
No Liquid during welding and very small heat affected zone

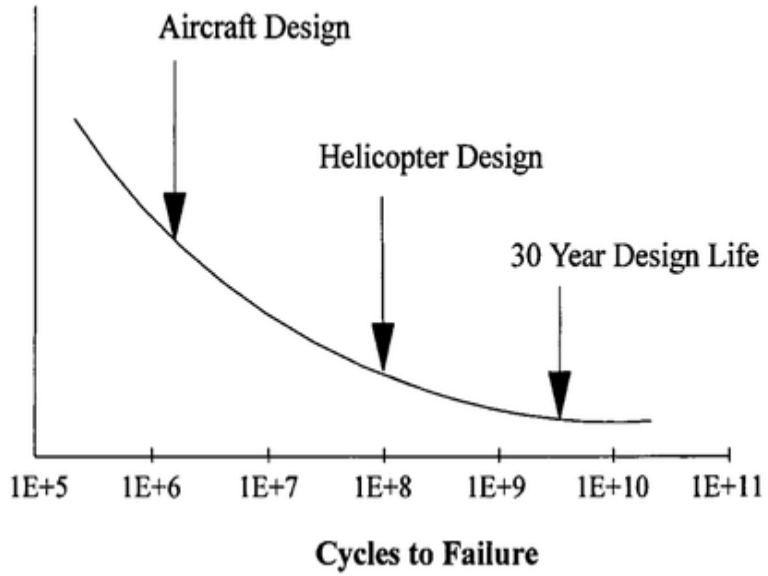
5–15% Better strength in comparison with MIG and better plasticity

Flexibility For the creation of different width using standard panel shape, low extrusion pressure

MOVING TOWARDS ROAD BRIDGES

Road bridges have much higher loads and serve fatigue loads due to intensive traffic. Additionally Russian regulations require fire endurance limits





Results of the fire testing of the orthotropic 6082T6 panels (with asphalt layer):

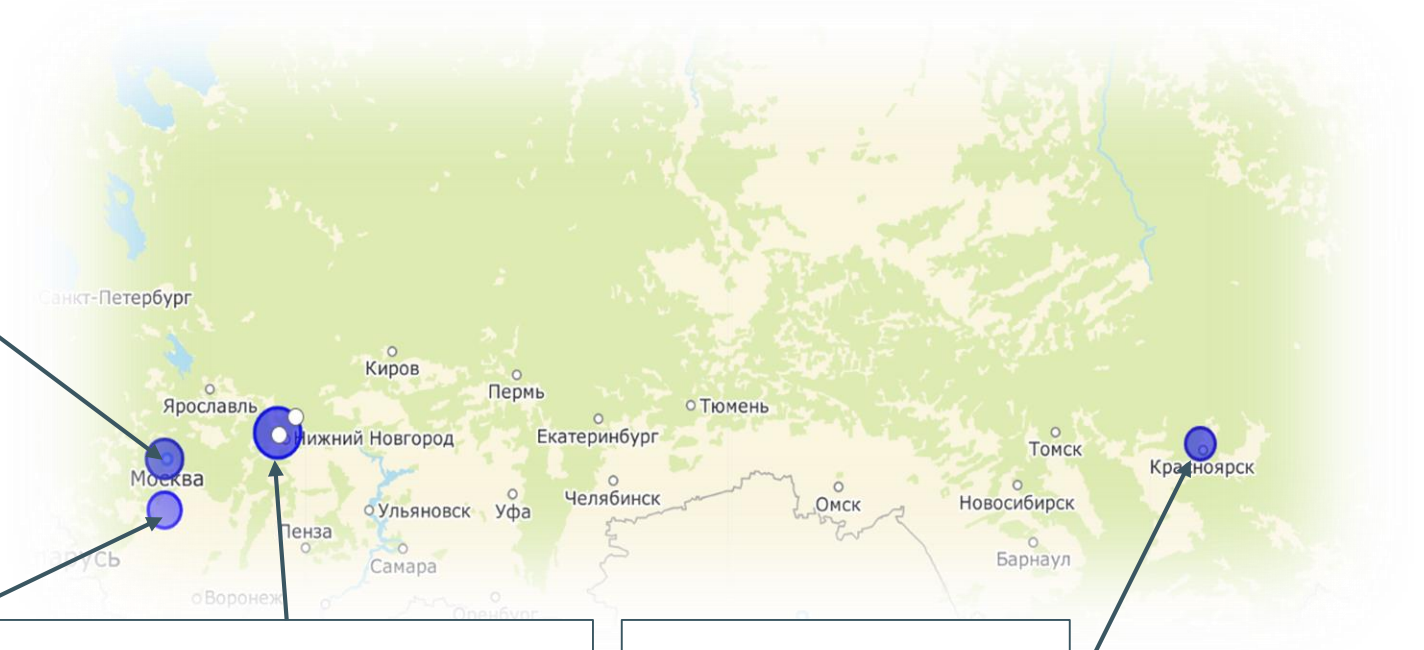
- **REI 45**- fire endurance
- Maximum bending during tests – **65 mm**.

- Development of the road coating for the bridge flooring and testing during the fatigue performance
- S-N curves creation as the baseline for life prediction and calculations – new requirements for the alloy choice.

ALUMINIUM BRIDGES OF TODAY

8 pedestrian aluminium bridges constructed and installed since 2017

Moscow
2 objects



Tula
1 object

Nizhniy Novgorod
region - 2 objects

Krasnoyarsk
3 objects

РУСАЛ · КраМЗ · AMP Белая Калитва · ARCONIC · ГРУППА КОМПАНИЙ ГС РЕЗЕРВ · СЕСПЕЛЬ · гипростройМОСТ

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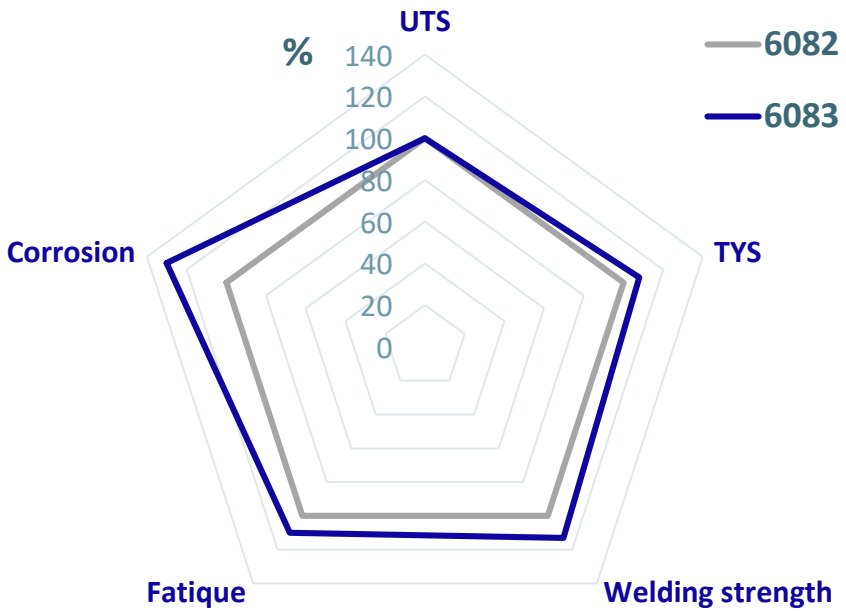
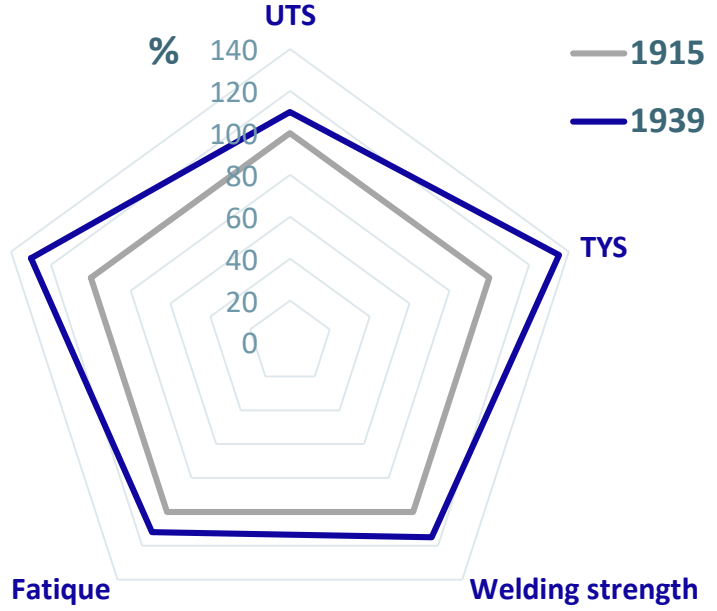
MATERIALS: FUTURE VIEW

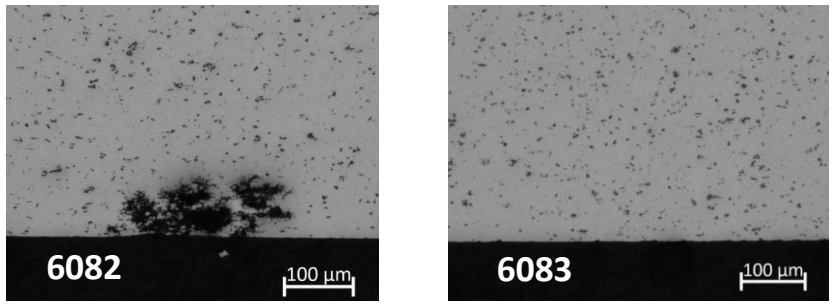
RUSAL 6083 (Al-Mg-Si) alloy



The main idea for the creation of new alloys is to increase weight and metal efficiency of the bridge constructions of new generation together with lifetime

RUSAL 1939 (Al-Zn-Mg) alloy





Results of IGC tests

New alloys have been tested for the inclusion in current rules for design of bridges

FSW

MIG

Both alloys are weldable

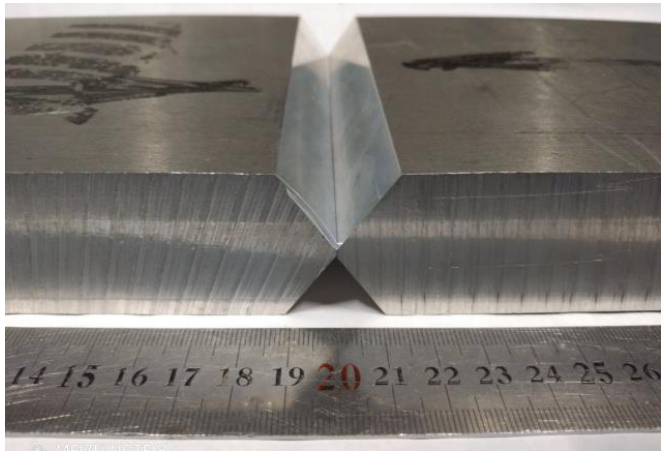
MATERIALS: FUTURE VIEW

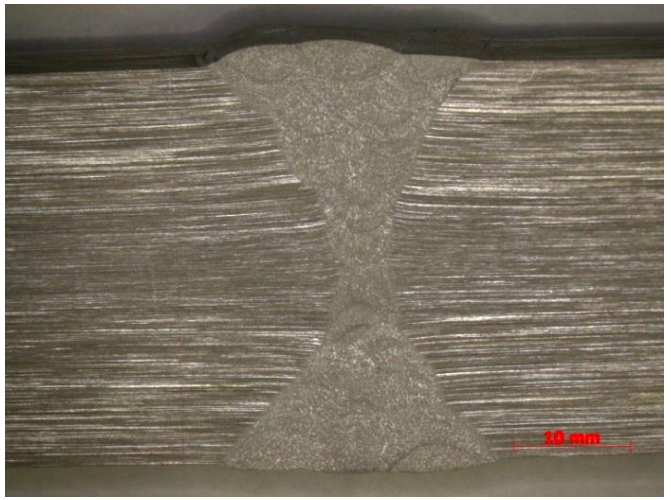
Al-Mg-Sc may be the material of choice for bridge structure as it accumulates weldability and corrosion of 5XXX aluminium but with 20% more strength

	AlMg5Mn	5181 (Al-Mg-0,03Sc)	
UTS, (MPa)	300	355	**(+18%)**
TYS, (MPa)	140	205	**(+45%)**
Weldability (%)	90	90	
Weld strength	270	320	**(+18%)**
Fatigue, (MPa)	55	100	**(+81%)**

Up to **30%**

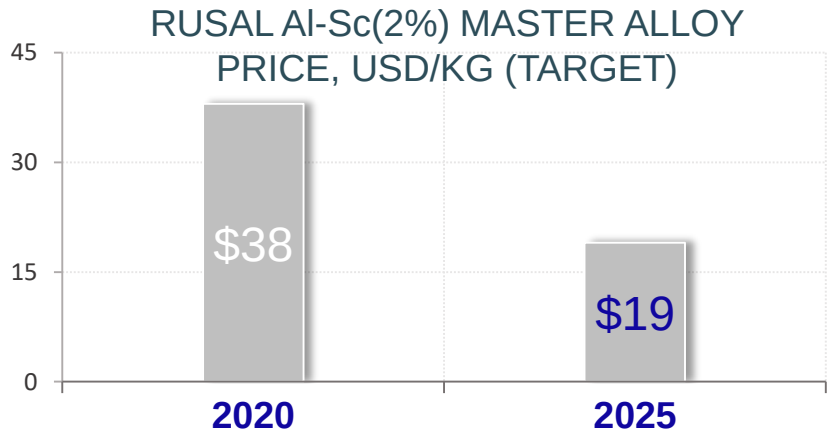
Reduction of weight for bridge structures especially in welded structures





RUSAL developed own chain of leaching Sc203 from red mud with further processing into master alloy

In case of market growth addition of 0,03% will bring only **10%** of additional price to aluminium alloy



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Thank you!

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