

Technical Manual



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>> 正交异性钢桥面板U肋全熔透焊接技术
100% Penetration Welding Solution For
Orthotropic Steel Bridge Decks With U-ribs

武汉天高熔接股份有限公司
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公司简介

Company Profile

武汉天高熔接股份有限公司（简称：天高，证券代码：831559）成立于2001年，是一家集焊接材料、焊接工艺技术与设备的研发、生产、销售于一体的高新技术企业。其中，天高以显著的优势成为全球最大的陶质焊接衬垫生产基地。

天高通过ISO9001质量管理体系认证，持有CCS、ABS、LR、DNV-GL、BV、RINA和NK等多国船级社认可证书，拥有自主专利几十项。是国家高新技术企业、国家两化融合试点企业、省创新型建设试点企业、省重点培育企业、省知识产权示范建设企业、博士后创新实践基地、博士后工作站等；天高商标被评为省、市著名商标；天高技术中心被认定为省、市级企业技术中心。

天高是陶质焊接衬垫产品国际ISO和国家行业标准的起草者，主导产品荣获国家重点新产品、中国专利优秀奖、省科技进步奖、省名牌产品、省自主创新产品称号。天高牌衬垫和埋弧焊剂在桥梁工程上占据重要市场份额。其中，公司为世界最大跨度公铁两用斜拉桥——沪通长江大桥Q500qE高强度钢开发出匹配的埋弧焊材料，成为技术性能唯一达标的指定品牌。



图为：世界最大跨度公铁两用斜拉桥——沪通长江大桥
Hutoing Yangtze River Bridge



WUHAN TIANGAO WELDING CO., LTD. (Tiangao for short, stock code: 831559), established in 2001, is a high-tech company integrating R&D, production and sales of welding consumables, processes, technologies and equipments. Now Tiangao is the biggest production base of ceramic weld backings in the world.

As an ISO9001 certified company, Tiangao has dozens of patents, CCS, ABS, LR, DNV-GL, RINA and NK certificates. Tiangao is National High-tech Company, National Pilot Demonstrative Enterprise of Industrialization and Informatization, Provincial Pilot Enterprise of Innovation, Provincial Key Cultivated Enterprise, Provincial Model Enterprise of Intellectual Property Management, Postdoctoral Practice Base and Postdoctoral Workstation. "Tiangao" is a Provincial and Municipal Famous Trademark. And Tiangao's technological center has been certified as Provincial and Municipal Level Company Technological Center.

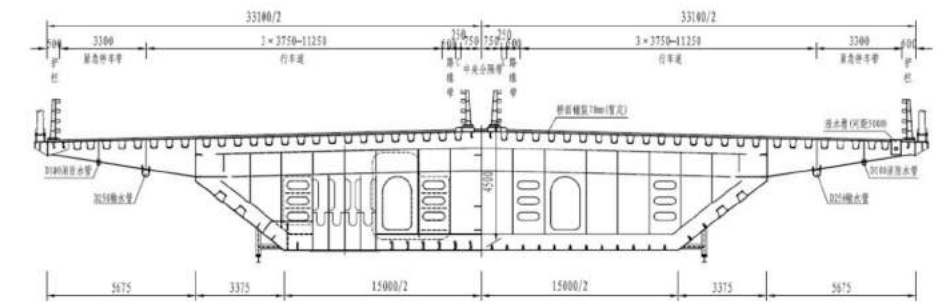
Tiangao has drafted ISO and national standards for ceramic welding backings. The leading product has won the titles of National Key New Products, Excellent Chinese Patent Award, Provincial Scientific and Technological Progress Awards, Provincial Famous Brand Products, Independently Innovated Products of Hubei Province etc. TG series of ceramic backings and SAW fluxes gain a significant market share in bridge engineering. And Tiangao custom-made SAW consumables are the only conforming and designated ones for Q500qE high-strength steel of Hutong Yangtze River Bridge, the world's largest span highway-railway cable-stayed bridge.

项目背景

Project Background

正交异性钢桥为世界桥梁界所推崇——自重轻、材质均匀、质量稳定、易于工厂化制造、装配化施工、便于回收利用等优点，被大量应用于大跨度桥梁中。

我国在不到20年的时期内建成了上百座大跨度钢桥，这一建设速度、数量、规模世界上史无前例。但是随着其广泛应用，桥梁服役过程中焊接接头的疲劳问题也日益显现，尤其是出现在U型肋板与桥面板间纵向焊缝处的疲劳裂纹，不但极大削弱了桥面的承载功能和使用寿命，而且难以修复，成为桥梁界被高度关注而始终未能得到圆满解决的国际性难题。



图为：港珠澳大桥断面
Section of Hong Kong-Zhuhai-Macau Bridge

Orthotropic steel decks are widely applied in large span bridges due to their light weight, material consistency, stable quality, easy production in factory, rapid erection and convenient recycling.

In less than 20 years, China has built nearly one hundred large span bridges, which is unprecedented in speed, quantity or scale in the world. However, the fatigue problem in weld joints gradually appears with the wide application, especially the fatigue cracks found in rib-to-deck weld joints, which substantially weakens the load capacity and shortens the lifespan of the bridges. What's more, it is hard to repair the cracks. This issue has become an international concern for bridge industry without a satisfactory solution.



国内外U肋焊接现状

Domestic and Overseas U-rib Welding

服役中钢桥U肋与面板连接纵缝的典型疲劳裂纹案例 >>

Typical Cracks in Rib-to-deck Weld Joints of Steel Bridges in Service

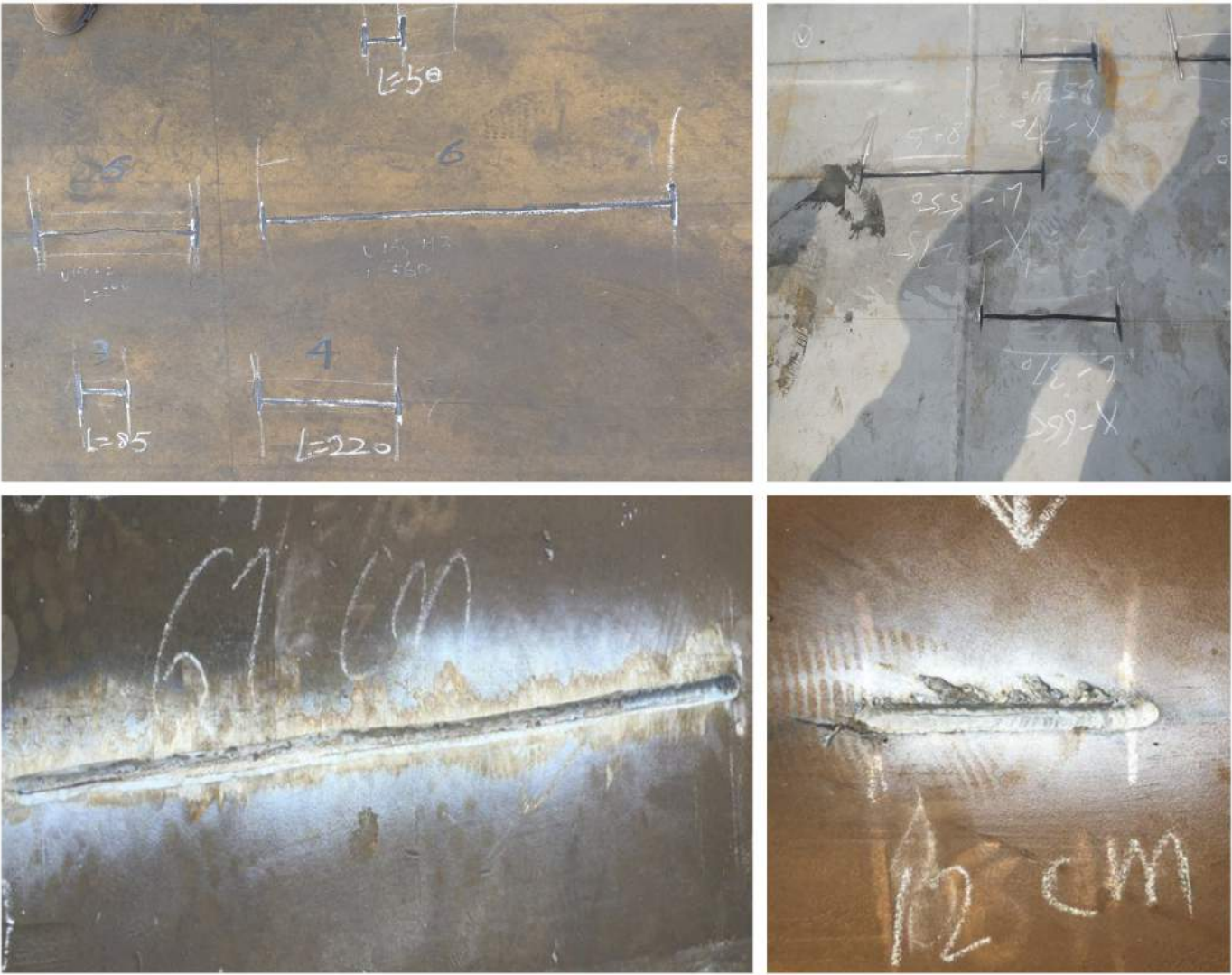


图为：裂纹扩展至桥面板
Cracks Extend to Decks



国内外U肋焊接现状

Domestic and Overseas U-rib Welding

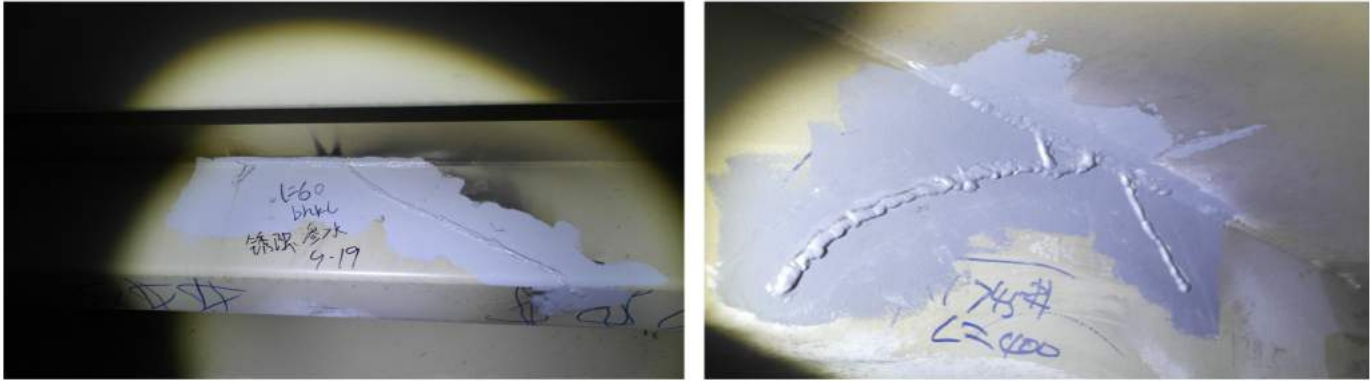


图为：掀开铺装U肋裂纹隐藏于桥面板的焊根
Cracks in Rib-to-deck Weld Roots Hidden under Pavements



国内外U肋焊接现状

Domestic and Overseas U-rib Welding



图为：裂纹扩展至U肋腹板
Cracks Extend to U-rib Plates

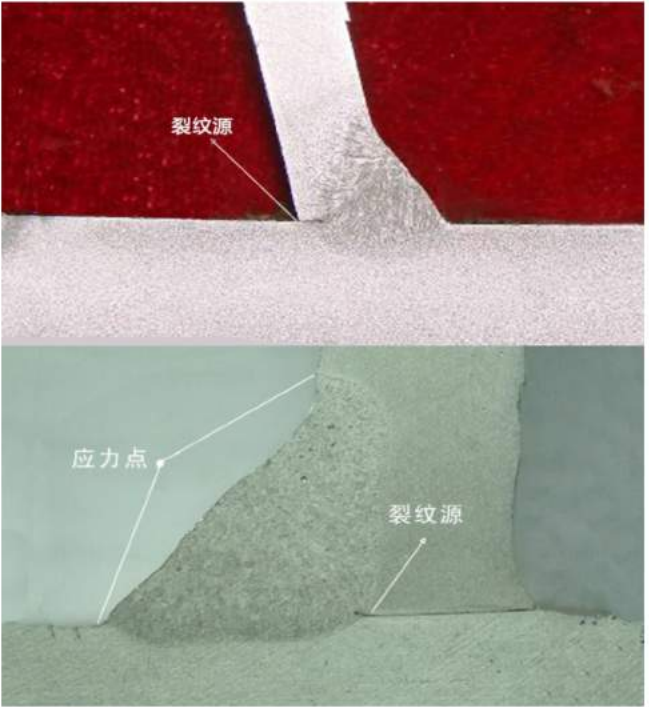
类似照片上的裂纹，不同时期投入运营的钢桥都存在。这种局面，有车辆严重超载的国情因素，但真正的病根出在U肋焊接！
Cracks similar to those in the pictures exist in steel bridges no matter when they came into service. Serious overload in China maybe one of the causes, but the fundamental cause lies in U-rib welding.

U肋焊接存在的问题 >>

Problems of U-rib Welding

U肋与钢桥面板间的焊接简称“U肋焊接”。U肋内断面呈梯形，一般底宽×高为300×280mm，板厚多为8~10mm，每根长度至少8米以上。细长的空腔结构制约了焊接作业，国内外设计均要求在U肋外侧单面施焊，熔透深度定为70%~80%。尽管各国规范略有差异，但焊缝内侧根部缺陷与生俱来始终存在。再加上在焊接过程中还存在许多不确定因素：

U-rib welding is short for welding U-ribs to decks. The internal section of U-rib is a trapezoid, normally bottom base width x height is 300×280mm, plate thickness is 8-10mm, and length is 8 meters or above. The narrow and long cavity structure limits welding operation, so it is required that single-side welding at the outside of U-rib should reach 70-80% penetration in domestic and overseas design of steel bridges. Although the standards of different countries have some slight differences, the defects inside the roots are innate and lasting. What's more, there are many uncertainties during welding:



国内外U肋焊接现状

Domestic and Overseas U-rib Welding

- a. 焊接电流偏大、焊枪夹角偏差、U肋组装间隙过大等因素，均会导致焊接时击穿焊缝，在焊缝反面局部形成较大焊瘤的缺欠；
- b. 定位点焊较短及熄弧操作不当，定位焊存在裂纹难以根除，焊接时不可能清除，采用的CO₂焊又无法将其重熔，焊缝中必定存在较多的内部缺欠；
- c. 因顾虑焊接时可能击穿，焊缝熔透率很少能达到80%，有的甚至不足50%，焊缝的有效厚度也难以保证；
- d. 角接头无法采用X光拍片探伤，超声波探伤在8mm以下厚度探伤灵敏度不够，超声波相控阵探伤成本高。因此，U肋焊接多数只做磁粉探伤抽检，焊缝内在质量基本上是一种失控状态。

几十年来，U肋单面焊接工艺所带来的焊缝缺陷问题促使人们投入研究，努力探索新的焊接技术和方法。在智能技术领先的日本，多年前曾采用在U肋内部微型机器人用CO₂气保焊进行焊接。近年国内也有相近工艺应用，但U肋CO₂气保焊熔深虽达到80%，缺陷依然存在，问题未得到根本解决。
R&D in new technologies and methods for the solutions of U-rib welds has never stopped during the past decades. Japan, being advanced in smart technology, used micro-robot in the U-rib with CO₂ welding several years ago. And in recent years, similar methods are also used in China, but the problem is not solved fundamentally although the CO₂ welding penetration reaches 80%.

- a. When welding current is too large, welding torch angle deviates, or clearance of U-ribs assembling is too big, big overlaps at the back of the welds will appear due to burn-through during welding.
- b. When tack welds are short and arc extinction is not properly operated, cracks in track welds cannot be eliminated, and CO₂ welding cannot re-fuse the welds, so there must be many internal defects in the welds.
- c. To avoid possible burn-through, few welds reach 80% penetration, some of them cannot even reach 50%, and the effective weld throat cannot be guaranteed.
- d. Fillet welds cannot be tested with X-ray or ultrasonic test that only works for the thickness of 8mm and above, while the ultrasonic phased array cost is too high. Therefore only magnetic particle test is carried out for most of the U-rib welds, and the weld quality is actually uncontrolled.

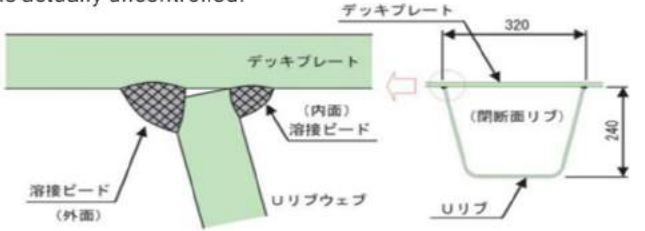


図-1 両面溶接Uリブ鋼床版構造

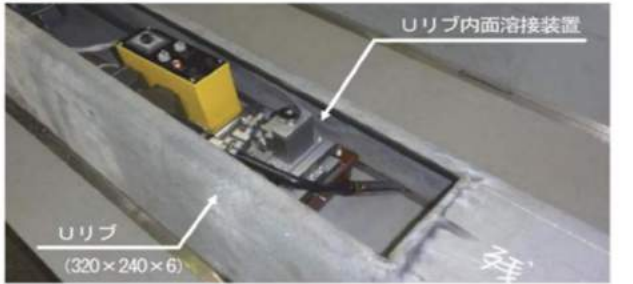
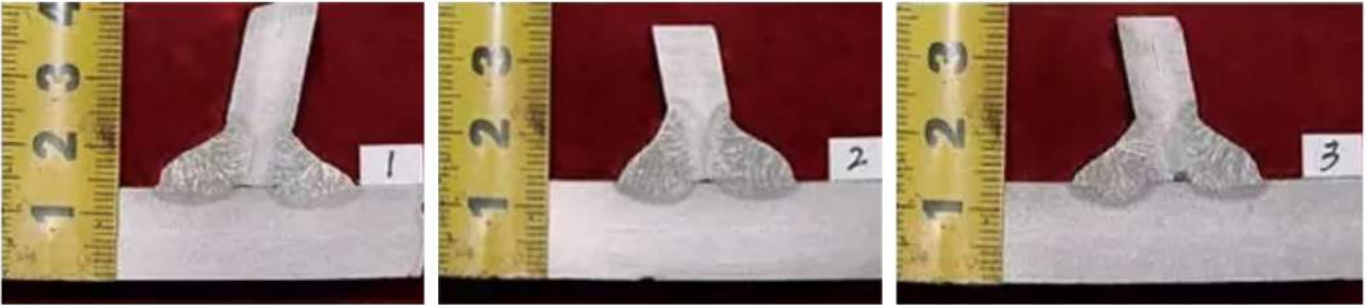


写真-1 Uリブ内面溶接装置



U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs

鉴于对焊接工艺、材料多年研究，积累以及钢桥制造过程、使用状况的考察调研，武汉天高熔接股份有限公司技术团队，把消除焊接缺陷、实现全熔透焊缝作为攻克目标，从工艺、材料、装备等全方位进行系统的研究开发，成功推出了一种全新思维模式的制造方法，即UFB法。

After years of experience in R&D in welding processes and materials, Tiangao technical team has completely investigated steel bridge construction and service, and successfully found a brand-new welding method, UFB, which can eliminate weld defects, and realize 100% penetration for U-rib welding.

UFB法简介 >>

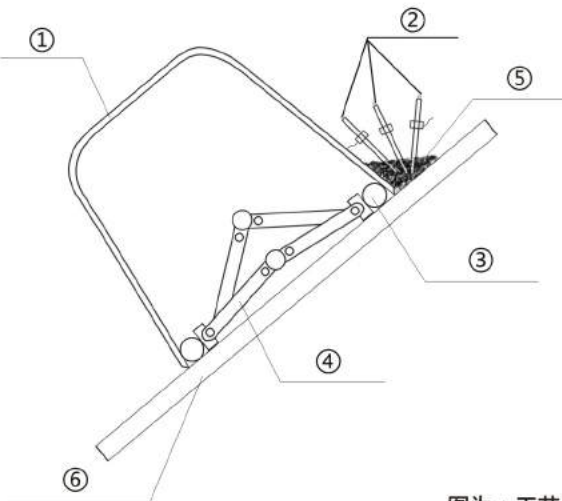
Brief Introduction of UFB

UFB法是指在正交异性钢桥面板单元施工过程中，先在U肋内侧接头处装贴陶质衬垫，然后在外侧采用双电源多丝埋弧焊，实现U肋与桥面板连接接头单面焊双面一次成型的全熔透焊接方法，简称U肋埋弧衬垫焊（其中，U：U肋，F：焊剂，B：衬垫）。

UFB (abbreviation stands for U-rib submerged arc welding with flux & backing) method: when welding U-rib to orthotropic steel decks, ceramic backing is installed inside the U-rib, double-power-multi-wire submerged arc welding method is taken outside to achieve one side welding both sides formation with 100% penetration at the rib-deck joint.



图为：U肋焊接实景
Real-life Picture of U-rib Welding

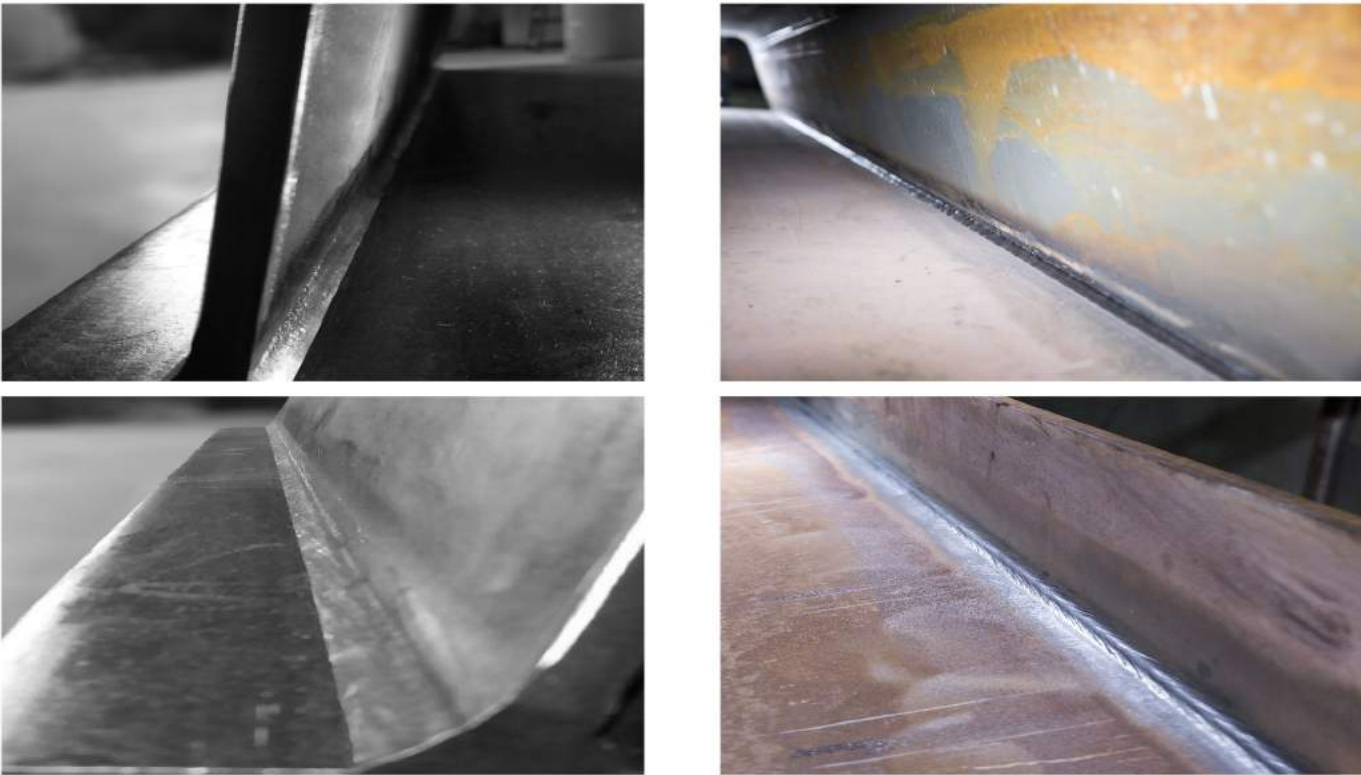


图为：工艺原理
Principle Diagram

- | | | |
|-------|-------|------------------|
| ① U肋 | | U-rib |
| ② 焊枪 | | Welding Torch |
| ③ 软衬垫 | | Flexible Backing |
| ④ 撑架 | | Support Bracket |
| ⑤ 焊剂 | | Flux |
| ⑥ 面板 | | Deck |

U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs



图为：UFB法焊缝成形
UFB Weld Pictures

UFB法从根本上解决了以前U肋焊接存在的缺陷，主要体现在以下方面 >>

UFB method has eliminated the U-rib weld defects, as shown in the following aspects

- 创新工艺，确保焊接质量，提高工效
Innovative process that ensures weld quality and improves efficiency

- 埋弧焊熔深大，焊缝质量好，便于实现自动化，焊接效率高，能真正将点焊点重熔，以实现全熔透焊接；
The SAW has the advantages of deep penetration, high weld quality, easy automation, high welding efficiency and full re-fusion of the tack welds to realize 100% penetration.
- 采用特制柔性衬垫，能够保证在工艺条件变化时（间隙、钝边、坡口角度，点焊）的熔透率，防止焊穿、焊瘤出现；
Custom-made flexible backings can ensure penetration when the welding conditions differ (clearance, root face, groove angel, tack weld) and prevent burn-through and overlap.

U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs

● 通过合理匹配外焊电流、电压、焊接速度、焊丝间距、冷丝送丝速度等，保证填充、焊缝质量、焊角尺寸和焊缝表面成形；

The filling, weld quality, fillet size and surface formation are guaranteed by reasonably matched outside welding current, voltage, speed, clearance between wires, feed rate of cold wires, etc.

● 电流、电压、焊接速度、焊丝角度的良好匹配，修复焊缝，提高并确保焊接质量；

The inside of fillets can be repaired with reasonably matched current, voltage, speed and wire angle, and fillet quality can be improved and ensured.



图为：修复焊缝影像
Images of Weld Repair

● 采用了内侧焊缝衬垫强制成形，外侧焊缝处于船形位置施焊，可确保内外侧焊缝外形呈内凹圆弧状光滑过渡，同时也有效克服焊趾处的咬边和焊缝中间出现的多余余高，使焊缝接头的应力分布更合理，从而提高了接头疲劳寿命；

Inside of the welds, backings are attached to achieve forced formation, and outside, the fillets are welded in the flat position, so weld contours of both sides are concave with smooth transition, and undercut or excessive weld reinforcement can be avoided, making the weld joints stress distribution more reasonable, consequently the joint fatigue life is prolonged.



U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs

● 全熔透情况下，横向无变形，纵向变形小，修复处理简单。

With 100% penetration, lateral deformation will not appear and longitudinal deformation will be tiny enough to be repaired easily.

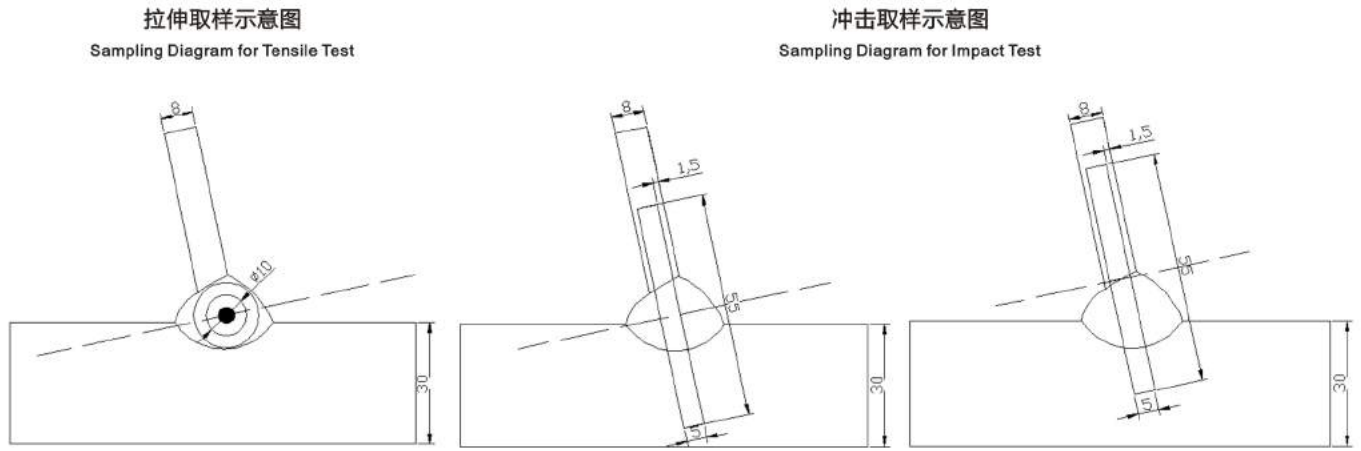
● 优化焊接材料和焊接工艺，有效提高接头力学性能

Joint physical performance is effectively improved by optimizing consumables and processes

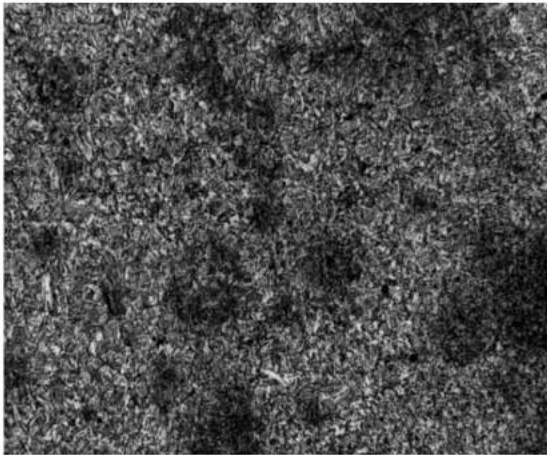
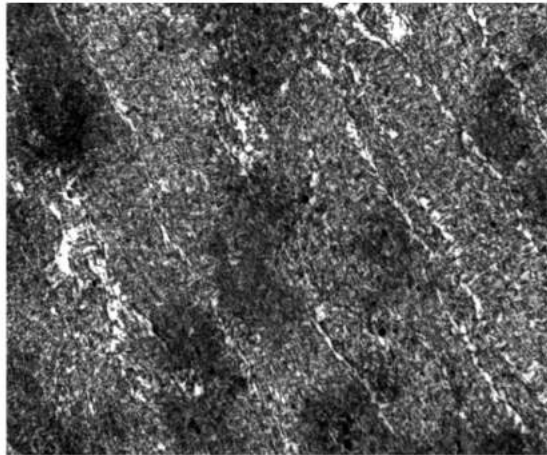
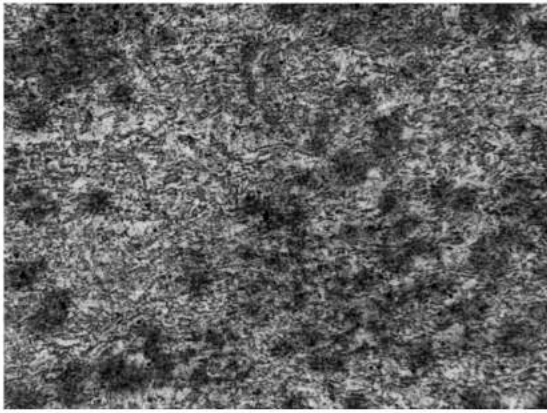
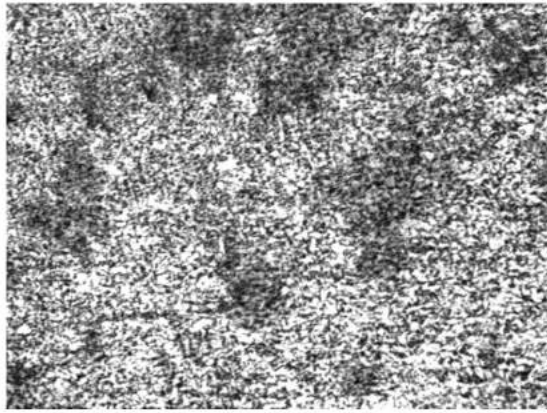
埋弧焊是公认的焊接性能最稳定可靠的焊接方法。在此基础上，优化焊接材料，可进一步确保焊接接头力学性能。我司具有较强研究开发、生产焊丝、焊剂、衬垫等焊材的能力，通过焊接材料相互配合，改善焊缝组织，保证低温韧性。

It is widely accepted that the welding performance of SAW is the most stable and reliable. And the optimization of SAW consumables can further ensure weld joint physical performance. Tiangao is strong in R&D and production of wires, fluxes & backings, and the consumables are made as a whole to improve weld microstructure and ensure low-temperature toughness.

焊接接头性能试验 Weld Joint Performance Test				
实验 Experiment	母材 Parent Metal	焊剂 Flux	衬垫 Backing	焊丝 Wire
—	Q345qD30mm+8mm	TGF-SJ988U	TG-U	H08MnA 3.2*1+4.0*1 ER50-6 1.6*1



焊接接头性能试验 Weld Joint Performance Test					
冲击试验 Impact Test					
试验 Test	取样位置 Sampling Position	试验温度 Test Temperature			
		-20℃	-30℃	-40℃	-50℃
—	焊缝中心 Weld Center	76、73、75	60、66、66	64、56、72	60、54、66
	U 肋腹板侧熔合线 Longitudinal Fusion Line of U-rib Plate	56、52、55	52、50、54	50、49、49	48、47、50
备注 Remark	试样尺寸为 55*10*5 冲击吸收功，换算为 55*10*10 冲击吸收功应≈测试值×2 The specimen's dimensions are 55*10*5, if convert the size to 55*10*10, the value of impact energy absorption roughly doubles the specimen's test value.				
拉伸试验 Tensile Test					
试验 Test	编号 No.	取样位置 Sampling Position	屈服强度(Mpa) Yield Strength	抗拉强度(Mpa) Tensile Strength	延伸率(%) Elongation
—	1-1	焊缝	527.52	617.65	26
	1-2	Weld	525.36	616.09	26

焊接接头金相试验 Weld Joint Microscopic Examination	
热影响区 Heat Affected Zone	焊缝 Weld
	
母材 Parent Metal	熔合区 Fusion Zone
	
试验结果显示：焊缝熔合良好，内部无缺陷，成形美观 The test results show: good weld fusion, no internal defects, smooth appearance.	

U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs



实现U肋焊缝的超声波探伤检测

Ultrasonic test is applicable for U-rib welds

UFB法焊接的U肋与桥面板能实现全熔透，采用超声波探伤检测能使焊缝质量得到有效保证。

UFB welding has realized 100% penetration of rib-to-deck joints and effective ultrasonic test for weld quality control.

			
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检测结果：100%熔透；无缺陷优质焊缝

Test result: 100% penetration, no defects in welds



采用专用焊接生产线，实现自动化标准生产

Standardized production with the special automatic welding manufacturing line

天高根据U肋全熔透焊接工艺特点，研发了龙门式六头焊接装置及摇摆变位板单元胎架的自动化焊接生产线。该生产线采用胎架移动方式，保证焊接时设备的稳定和焊接质量。自动化焊接生产线利用6个多丝机头，焊接速度600mm/min。自动化焊接生产线配套有焊接电流电压记录报警、在线视频监控、焊剂自动回收、焊接烟尘回收等系统，无明弧、无噪音、无烟尘，实现绿色智能制造。

Tiangao has developed an automatic gantry welding production line with 6 heads for 100% penetration of rib-to-deck joints. The line has turning rolls with swing units to guarantee the stability of welding machines and welding quality. 6 heads for multi-wire can weld at the speed of 600mm/min. And the line also has the green and smart properties including current and voltage recording and alarms, online video monitoring, auto flux recycling, auto fuse gathering, no visible arc, no noise, no smoke, etc.

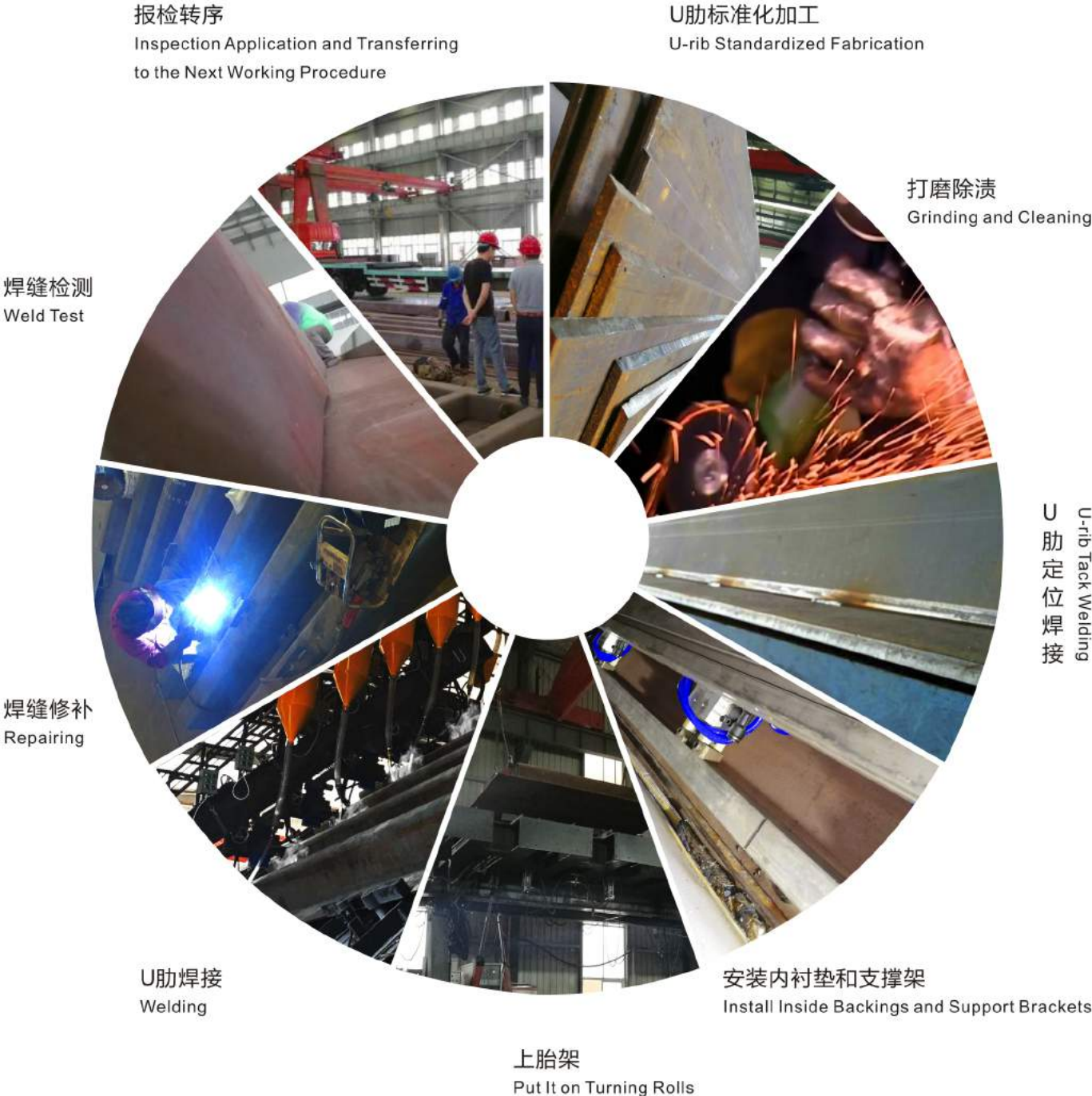


U肋全熔透焊接工艺及材料

100% Penetration Welding Process and Consumables for U-ribs

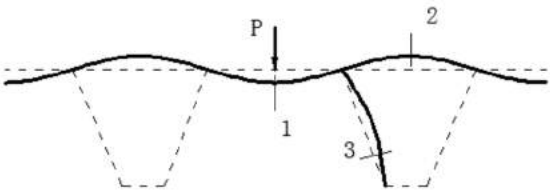
U肋生产流程

U-rib Fabrication Flow



U肋全熔透焊接接头疲劳性能检测
Fatigue Test of 100% Penetration Deck-to-rib Joints

专家来访及意见
Expert Visit and Comment



图为：疲劳实验原理
Fatigue Test Principle

为保证U肋接头焊接状况与实桥一致，实验试件均从正交异性钢桥面板结构上切割下来。试件材料为Q345qd钢。试件设计主要参数如下表：
To guarantee the U-rib joint welding is in accordance with that of real bridges, all the specimens are cut out from orthotropic deck structures, and the material of the specimens is Q345qd steel. Main parameters of the specimens are listed in the following table:

Table with 2 columns: Main Dimensions of The Specimens, and values for Thickness of the Deck (14mm), Length of the Deck (300mm), Thickness of the U-rib (8mm), Length of the U-rib (170mm), and Width of the Specimen (Longitudinal Length of The U-rib) (60mm).



图为：疲劳实验装置
Fatigue Test Devices

Table titled '检测结果 Test Result' containing specimen data: Specimen No., Specimen Process, Measured Stress, Number of Cycles, Crack status, and Average Number of Cycles. Includes a detailed note on fatigue test results and performance comparison.

Table with 5 columns: Specimen No., Specimen Process, Measured Stress, Number of Cycles, and Crack Description. Provides detailed crack analysis for specimens SWP75-1, DWP50-1, and UFB-1.

工艺评审 >>

Process Evaluation

2017年4月，在中铁大桥勘测设计院集团有限公司和湖北省焊接学会组织召开的《正交异性桥面板单元U肋全熔透焊接研究报告》专家评审会上，U肋全熔透焊接工艺及配套装备、材料通过了中铁宝桥（扬州）有限公司、中铁九桥工程有限公司、武船重型工程股份有限公司、中交二航局结构工程有限公司、中建钢构有限公司华中大区、武汉青山长江大桥建设有限公司、杨泗港长江大桥建设指挥部、唐山开元特种设备有限公司、武汉理工大学等相关单位组成的专家组评审。



In April 2017, 100% penetration welding process, equipments and consumables for U-ribs were approved in the review meeting of Research Report on 100% Penetration Welding for Orthotropic Steel Bridge Decks with U-ribs. It was organized by China Railway Major Bridge Reconnaissance Design Institute Co., Ltd. and Hubei Welding Society, and the review panel members included experts from China Railway Baoji Bridge (Yangzhou) Co., Ltd, China Railway Jiujiang Bridge Engineering Co., Ltd, Wuchuan Heavy Engineering Co., Ltd, China Communications 2nd Navigational Bureau Structure Engineering Co., Ltd.China Construction Steel Structure Corp. Ltd. (Central China Region), Wuhan Qingshan Yangtze River Bridge Construction Co., Ltd., Yangsigang Yangtze River Bridge Construction Headquarters and Wuhan University of Technology.

正交异性桥面板 U 肋全熔透焊接技术研究
成果评审会
专家评审意见
2017 年 4 月 21 日，中铁大桥勘测设计院集团有限公司和湖北省焊接学会暨武汉焊接学会在武汉市组织召开了《正交异性桥面板单元 U 肋全熔透焊接研究报告》专家评审会。
一、研究报告内容全面，符合评审要求；
二、针对正交异性钢桥面板 U 肋全熔透焊接的技术难点，研发了与其配套的焊丝、焊剂、衬垫及有效的衬垫装备工艺体系和焊接工艺，有效的实现了 U 肋的全熔透焊接及焊缝的质量检测和性能评价；
三、三种典型的 U 肋焊接接头对比疲劳试验结果证明：采用本工艺完成的全熔透 U 肋焊接接头具有良好的抗疲劳性能；
该项目技术理念先进、技术路线正确，具有创新性。建议根据本工艺成果研制完成 U 肋板单元焊接生产线，实现 U 肋板单元生产的工厂化。
专家组组长： 范文理
专家组副组长： 邢志军

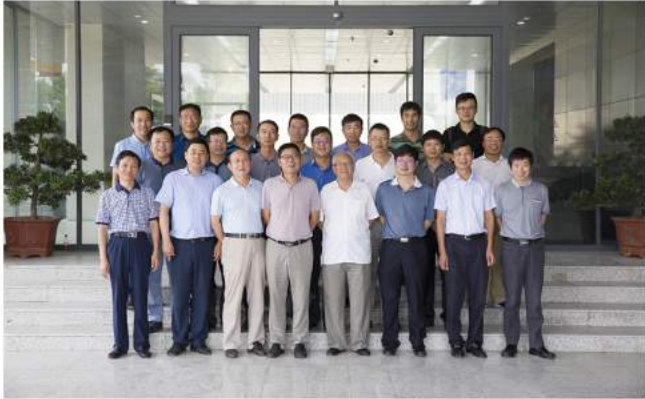
成果鉴定 >>

Achievement Appraisal

2017年8月，上海铁路局南京枢纽工程建设指挥部在武汉主持召开《五峰山大桥正交异性板U肋全熔透焊接应用研究》开题报告专家评审会，经由中国铁道科学研究院研究员程季青担任组长，中铁大桥勘测设计院集团有限公司、中铁大桥局集团有限公司、中铁九桥工程有限公司、中铁宝桥（扬州）有限公司、武汉国检检测技术有限公司、江苏沪宁钢机股份有限公司等相关单位专家组成的评审组鉴定，认定该项目技术理念先进，具有独创性。评审组一致同意项目通过鉴定，并认为实现U肋全熔透焊接不仅对五峰山特大桥具有研究价值，更对提高中国钢桥建造水平具有重要意义。



图为：评审会现场
Review Meeting



图为：评审专家组
Review Panel

In August 2017, Shanghai Railway Bureau Nanjing Pivotal Project Construction Headquarters organized the review meeting of R&D on Application of 100% Penetration Welding for Orthotropic Steel Bridge Decks with U-ribs in Wufengshan Bridge in Wuhan. Cheng Jiqing, a researcher of China Academy of Railway Sciences, acted as the panel leader, and the panel members included experts from China Railway Major Bridge Reconnaissance Design Institute Co., Ltd., China Railway Major Bridge Engineering Group Co., Ltd, China Railway Jiujiang Bridge Engineering Co., Ltd, China Railway Baoji Bridge (Yangzhou) Co., Ltd, Wuhan Guojian Testing Technology Co., Ltd and Jiang Su Huning Steel Mechanism Co., Ltd. The panel has approved the project, and agreed that the realization of 100% penetration welding for U-ribs is not only valuable for the research in Wufengshan Bridge, but also significant for improving Chinese steel bridge construction level.

五峰山大桥正交异性板 U 肋全熔透焊接应用研究
开题报告评审会专家意见

2017年8月25日，上海铁路局南京铁路枢纽工程建设指挥部在武汉市主持召开了《五峰山大桥正交异性板 U 肋全熔透焊接应用研究》开题报告专家评审会。中铁大桥勘测设计院集团有限公司、中铁大桥局集团有限公司、中国铁道科学研究院、武汉天高焊接股份有限公司、中铁九桥工程有限公司、中铁宝桥（扬州）有限公司、武汉国检检测技术有限公司、江苏沪宁钢机股份有限公司等单位代表和专家参加了会议。会议组成专家组（名单附后），专家组听取了五峰山大桥正交异性板 U 肋全熔透焊接应用研究开题报告汇报，经过讨论形成评审意见如下：

- 一、报告内容全面，符合评审要求；
- 二、该项目技术路线明确、研究方法正确。U 肋全熔透焊接技术理念先进，具有独创性；
- 三、实现正交异性板 U 肋全熔透焊接不仅对五峰山长江特大桥具有研究价值，该技术的研究对提高中国钢桥建造水平具有重要意义；
- 四、建议：
- （1）加强实物模型与实桥有限元分析的对比，使模型试验更加符合实桥受力状态；
 - （2）足尺疲劳试验的试件设计图，请相关单位尽快落实；
 - （3）进一步研究 U 肋工地嵌补段焊接技术。

专家组组长：程季青
2017.8.25

武汉青山长江大桥考察公司U肋全熔透焊接技术 >>

Technical visit of Wuhan Qingshan Yangtze River Bridge project personnel for 100% welding of U-ribs.



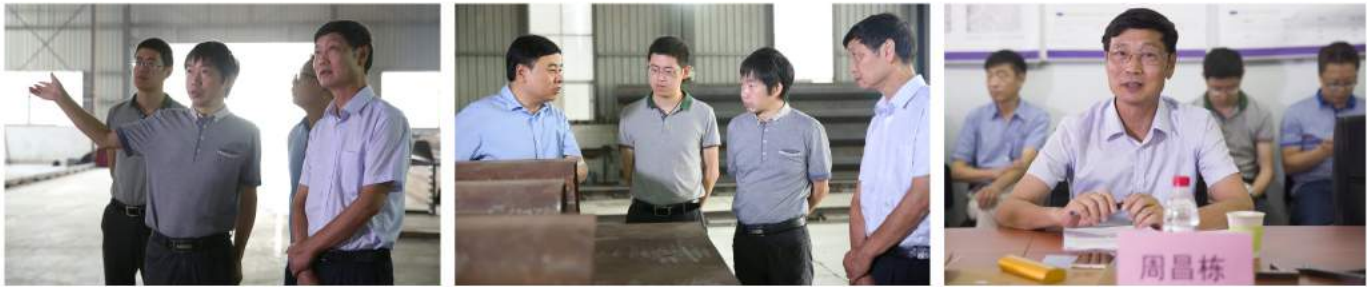
五峰山大桥考察公司U肋全熔透焊接技术 >>

Technical visit of Wufengshan Bridge project personnel for 100% welding of U-ribs.



宜昌伍家岗大桥考察公司U肋全熔透焊接技术 >>

Technical visit of Yichang Wujiagang Bridge project personnel for 100% welding of U-ribs.



专家来访及意见 Expert Visit and Comment

中建钢构有限公司总工程师戴立先等一行考察公司U肋全熔透焊接技术 >>

Chief engineer Dai Lixian and his party from China Construction Steel Structure Corp. Ltd. visited Tiangao for 100% welding of U-ribs.



湖北省交通规划设计院副总工程师张巍等一行考察公司U肋全熔透焊接技术 >>

Vice chief engineer Zhang Wei and his party from Hubei Provincial Communications Planning and Design Institute visited Tiangao for 100% welding of U-ribs.



湖北省交通投资集团副总工程师裴炳志等一行考察公司U肋全熔透焊接技术 >>

Vice chief engineer Pei Bingzhi and his party from Hubei Provincial Communications Investment Group Co., Ltd. visited Tiangao for 100% welding of U-ribs.



焊接人的中国梦，不抽象，
很具体。静下心，用工匠精神，
为中国桥梁事业贡献微薄之力！

孙小根